SCIENCE ABSTRACTS.

Section A.—PHYSICS.

MARCH 1924.

GENERAL PHYSICS.

365. *Acceleration of Gravity at the Melbourne Observatory.* **E. F. J. Love.** (Roy. Soc. Victoria, Proc. 36. 1. p. 21, 1923.)—This is a continuation of previous work. The value of *g* for Melbourne Observatory, when reduced to sea level, is 979·996. On applying Bouguer's correction this becomes 979·993 cm. per sec. W. R. C.

366. *Precise Length Measurements.* **J. E. Sears, Jr.** (Roy. Soc. Arts, J. 71. pp. 775–791, Oct. 5; 793–818, Oct. 12, and pp. 819–841, Oct. 19, 1923. Cantor Lectures.)—The author describes in outline the methods used for the maintenance of the fundamental standards of length, the yard and the metre, and their mutual comparison. He describes the principles underlying the use of wave-lengths as absolute units, and the manner in which the legal standards are determined in terms of wave-lengths. The methods used for comparison of sub-standards are described in some detail as well as the precautions which have to be taken in order to eliminate different classes of errors. The methods which have been used to overcome the difficulties encountered in length measurements to 10^{-6} inch are described in simple language. In particular, the method adopted at the National Physical Laboratory for preparing gauges of the Johansson type is given in some detail. The different apparatus used for the checking of screw gauges, including the projection apparatus, are described and illustrated. The whole paper forms a useful summary of the theory and practice of length measurements to the highest accuracy attainable to-day. J. W. T. W.

367. *A New Ocular Micrometer.* **H. Kellner.** (Optical Soc. of America, J. and Rev. Sci. Inst. 7. pp. 889–891, Oct., 1923.)—A new combination, presenting the advantages but not the defects of both the micrometer screw and the glass scale. A glass scale is adjusted by a sliding wedge and readings then taken to three places of decimals. Used by the Bausch & Lomb Optical Co. A. D.

368. *The Ultramicrometer used as a Differential Micromanometer.* **R. Whiddington and A. Hare.** (Phil. Mag. 46. pp. 607–608, Oct., 1923.)—

An arrangement of the ultramicrometer [Abstract 1350 (1920)] is described by which it was found easily possible to observe pressure changes of only 7 × 10^{-6} mm. of mercury at ordinary atmospheric pressures. The apparatus when fitted to any moving instrument performs the function of an amplifier of very great power. It is only intended for observing changes of length and will generally function not as an absolute but only as a differential manometer. J. J. S.

369. *Apparatus for the Measurement of Specific Gravity of Gases in Small Quantities.* **A. Blackie.** (Fuel Research Board, Sci. and Indust. Research Dept., Techn. Paper, No. 5. [6 pp.] 1922.)—A column of the gas under investigation is balanced against an equal column of air, the difference of pressure being measured by means of a Chattock tilting gauge. The two columns are contained in long thin copper tubes which are encased together with another long thin copper tube, forming the bulb of an air thermometer, in an outer copper water jacket to be used for temperature control. Perforated copper drums are attached to the free ends of the gas and air tubes, thus preventing any irregularities in the effective height of the columns of gas owing to diffusion, and reducing to a negligible quantity the effect of movement of gas in the tubes during the manipulation of the gauge. In the region of 0·4 to 0·6 specific gravity results are obtained which are correct within ± 0·5 %. For two separate measurements, including the cleaning of the tubes in each case, 1¼ litres of gas are necessary. A. B. C. L.

370. *Specific Gravity of Absolute Ethyl Alcohol at 20°.* **C. N. Riiber.** (Zeits. Elektrochem. 29. pp. 334–338, July 1, 1923.)—The specific gravity of absolute ethyl alcohol saturated with air is found to be: $d_4^{20} = 0{\cdot}789334 \pm 0{\cdot}000003$. The value for the air-free alcohol is higher than this by about 0·000075. T. H. P.

371. *Density of Charcoal by Displacement of Liquids.* **J. B. Firth.** (Faraday Soc., Trans. 19. pp. 444–447; Disc., 447–449, Nov., 1923.)—The apparent densities of cocoanut-shell charcoal and sugar charcoal have been determined by the displacement method in water, alcohol, benzene, and chloroform. The apparent density of the charcoal increases with the time of contact between liquid and charcoal, about fifty days being required for the value to become constant. The rate of change of density and the difference in the observed densities in the various liquids are largely determined by the sorption attraction between the charcoal and the liquid and, to a less degree, by capillary forces. A. A. D.

372. *Simple Densitometer for Accurate Work.* **G. R. Harrison.** (Optical Soc. of America, J. and Rev. Sci. Inst. 7. pp. 999–1002, Nov., 1923.)—A detailed description of a radiomicrometer. Briefly, the body of the instrument consists of a one-inch brass tube 40 cm. long soldered to a flat base, which is mounted on a wood sub-base with levelling screws. A torsion head is provided at the top and two windows are cut in opposite sides of the tube near its base. The coil is mounted on a small glass staff which holds a mirror 1 cm. diameter and a hook at the top; and to the bottom of the coil is soldered a fine wire thermojunction. The suspension is by quartz fibre. The permanent magnet is not built into the body of the instrument, as it was found more convenient to move it about. Careful screening from air currents was necessary, and a soft iron screen was used to procure steadiness and overcome the effect of the magnetic material in the coil. The optical system used was similar to those employed in the Koch microphotometer. The operation of the instrument is described, and the author concludes by saying that a very satisfactory densitometer can be constructed by using the radiomicrometer as a measuring instrument. [See Abstract 2088 (1909).] T. C. H.

373. *The Chain Balance.* **F. Petrie** (Journ. Sci. Instruments, 1. p. 29, Oct., 1923.)—In order to reduce the labour of weighing a large number of approximately equal ancient weights, a chain balance was used to determine the odd grains, the nearest hundred being taken by weights in the pan. A long flexible chain is hung by one end to the pan, and by the other to a pointer sliding on a vertical scale. Another advantage found is that by manipulation of the pointer, vibration can be quickly damped. W. G. B.

374. *A Direct-Reading Balance.* **R. Fortrat.** (J. de Physique et le Radium, 4. pp. 268–271, Aug., 1923.)—A description is given of a new form of balance which enables the density either of a solid or a liquid to be determined by a single reading. The principle of this direct-reading balance depends upon a scale beam having unequal arms; each arm, instead of being horizontal as in the usual case, is inclined to the horizontal. Further, the extremities of the two arms are situated below the horizontal through the fulcrum. Calling the lengths of the arms l and l_1, and their inclinations to the horizontal α and β, respectively, then, if P and p be the balancing weights in this equilibrium position, $Pl \cos \alpha = pl_1 \cos \beta$; the sensibility is given by $\frac{d\alpha}{d\delta}$, where $\delta = \frac{l_1 \cos \beta}{l \cos \alpha}$. The value of $\frac{d\alpha}{d\delta} = \frac{l \cos^2 \alpha}{l_1 \sin \phi}$, where ϕ is the included angle between the beam arms.

The sensitivity is therefore a maximum when ϕ is nearly equal to π. It is infinity when $\phi = \pi$ $\left(\text{except when } \alpha = \frac{\pi}{2}\right)$.

The sensitivity is a maximum when the density is such that $\alpha = 0$.

In practice the shorter arm with its adjustable weight carries a pointer, moving over a scale, the angular readings of which enable the weights of a body in air and in a liquid of known density to be measured. The paper includes an account of typical results obtained with the balance. A. W. J.

375. *Weight-Mass Ratios: New Gravitational Experiments.* **C. F. Brush.** (Am. Phil. Soc., Proc. 62. 3. pp. 75–89, 1923.)—Following the pendulum experiments of a previous paper [see Abstract 449 (1922)], the author has now constructed pendulums with bobs of lead, alloy, bismuth, the bobs being of the same shape, size, and weight (the latter equality attained by drilling holes). The lead bob was found faster than the alloy by 1 in 150,000, and faster than bismuth by 1 in 170,000. The difference between the alloy and bismuth was too small for certain detection. An entirely different method was also tried, the falls of equal containers with contents consisting of different metals being timed. Here lead was the fastest in falling, then bismuth, zinc, tin, and aluminium. Eötvös, however, found the weight-mass ratios of brass, glass, antimony, and cork to differ by less than 1 in 20,000,000. E. H. B.

376. *Measuring the Internal Diameter of Transparent Tubes.* **J. S. Anderson** and **G. Barr.** (Journ. Sci. Instruments, 1. pp. 9–15, Oct., 1923.)—Two methods: (1) Immersing the tube in a suitable liquid and varying the wave-length of the illuminating beam until equality of refractive index is attained so that, the system being now homogeneous, the diameter can be measured directly; (2) taking an X-ray shadow photograph of the tube and measuring the image formed. Between the two methods accurate measurements can be effected no matter what the outside shape of the tube may be. A. D.

377. *Extensometer Amplifier.* **S. R. Williams.** (Optical Soc. of America, J. and Rev. Sci. Inst. 7. pp. 1011–1013, Nov., 1923.)—A device for multiplying the effect of any linear displacement. A square brass rod is the mechanical lever whose fulcrum is a fine steel cambric needle passing through the rod and resting in a slot on a fixed support. There is a slot in the rod in which rests a knife edge forming part of a stirrup which is attached to whatever it is desired to measure the change in length. The outer end of the lever has a fine vertical hole bored through it, so that the mechanical advantage of the lever is six. A strip of fine phosphor-bronze ribbon is dropped through the hole and passes round a reduced section of a brass roller running in agate bearings, a small weight being attached to the lower end of the strip to keep it taut. A concave mirror is fastened to the roller, and as the hole moves up and down due to the movement of the slot in the rod this mirror is tipped and the deflection may be read off from the spot of light reflected from it. The method of calibrating is described. T. C. H.

378. *Elasticity of Metals.* **W. Geiss.** (Zeits. f. Metallkunde, 15. pp. 297–302, Nov., 1923.)—The relationship between the load and extension and elasticity of a metal is investigated. Hooke's law is extended and the elastic deformation of a metal is divided into a pure elastic deformation, and a deformation caused by after effect. The pure elastic deformation rigorously follows the law of proportionality, and is a characteristic constant of the material. It is independent of both the assumption and the previous treatment. The theory is supported experimentally by the fact that metal crystals free from after effect do not show deviation from Hooke's law. [See Abstract 8 (1907).] F. J. B.

379. *Volume Changes of Five Gases under High Pressures.* **P. W. Bridgman.** (Nat. Acad. Sci., Proc. 9. pp. 370–372, Nov., 1923.)—The observed changes of volume, in c.c. per mol., for the gases H_2, He, N_2, NH_3, and A, for pressures from 3000–15,000 kg./sq. cm. In the case of the first three, the molar volume at 3000 kg./sq. cm. is known, and so these results extend our knowledge of the molar volume to 15,000 kg./sq. cm. It is found that the diatomic gases retain their compressibility at high pressures, and this suggests that the complex molecule itself is undergoing compression. W. G. B.

380. *A Piezo-Electric Method for the Measurement of High Pressures.* **J. C. Karcher.** (Bureau of Standards, Sci. Papers No. 445. pp. 257–264,

1922. Frank. Inst., J. 194. pp. 815–816, Dec., 1922. Abstract.)—For the instantaneous measurement of high pressures the piezo-electric qualities of quartz are utilised. The amount of charge liberated from a perfect crystal is given by P. Curie as $6 \cdot 32 \times 10^{-8}$ e.s.u. per dyne, or approximately 10^{-11} coulomb per pound for small loads. Quartz plates were subjected to pressures up to 50,000 lbs. per square inch in a testing machine, and the relationship between charge and pressure was found to be linear over the full range of pressures used. The gauge was made by using a stack of quartz plates with thin metal electrodes between adjacent plates. The increased area thus obtained gives more charge. Unlike tourmaline, quartz yields no charge when exposed uniformly to hydrostatic pressure, so that the stack of plates must be inserted in a gas-tight housing, and the pressures must be applied in the direction of the axis of the stack by means of a piston plunger, one end of which is in contact with the stack while the other is exposed to the gas pressures to be measured. W. R. C.

381. *Motion of Oil Drops in Carbon Dioxide, Oxygen, and Helium at Low Pressures.* **J. M. Eglin.** (Phys. Rev. 22. pp. 161–170, Aug., 1923.) —The coefficient of viscosity of carbon dioxide determined by the oil-drop method is found to be $1 \cdot 478 \times 10^{-4}$ at 23° C. and 760 mm. pressure. This agrees with values found by the constant deflection method. The motion of oil droplets in carbon dioxide, oxygen, and helium has been observed at pressures of 1·9, 2·0, and 10 mm. respectively, and at values of l/a (ratio of mean free path to oil-drop radius) of 76, 130, and 71 respectively. The empirical correction factor to Stokes' law suggested by Knudsen and by Millikan, *viz.* $f\left(\frac{l}{a}\right) = \left(1 + \frac{l}{a}\right)\left(A + Be^{-\frac{Ca}{l}}\right)$ was found to hold for all. The results are finally compared with the equations given by Lenard and Langevin for large ions, and it is shown that the oil droplets obey the same laws. A. A. D.

382. *Wetting of Solid Surfaces.* **H. Devaux.** (J. de Physique et le Radium, 4. pp. 293–309, Sept., 1923.)—A body dipped in water emerges (*a*) covered with a continuous film of water, which persists (perfect wetting); (*b*) without adhering water (no wetting); (*c*) with a continuous film which soon breaks either spontaneously or by slight local heating and draws aside leaving the surface bare (poor wetting). Attentive study of the persistence of such a film thus gives valuable information as to the wetting of solid surfaces by liquids. Clean surfaces, *i.e.* surfaces for which the wetting is good, are simply obtained by passage through a flame. By suitable devices even films of tri-palmitine can be formed on the surface of a sheet of glass. By forming thinner and thinner layers it is shown that the wetting of a glass surface is completely prevented by the presence of a continuous layer of tri-palmitine of only mono-molecular thickness. In other words, wetting depends on actual contact between the molecules of the water and the surface. The capacity for being wetted is thus a property localised in the extreme surface layer of the molecules of a body. Further experiments show that materially to spoil wetting it is not even necessary that the layer of tri-palmitine should be continuous, one-fifth of the surface density necessary for continuity being adequate. Similar results are found when olive oil is substituted for tri-palmitine. Here the reverse process shows itself, *i.e.* a mono-molecular layer of moisture is sufficient to prevent the oil from "taking" on the surface, which must be dried by heating. Once the oil has "taken," a discontinuous layer with only one-third of the surface density of a continuous mono-molecular layer is adequate materially to spoil wetting by the water, and wetting is completely prevented by a continuous mono-molecular layer.

G. A. S.

383. *Capillary Phenomena at the Surface of Separation of Water and Vaseline Oil in Presence of Fatty Acids and Alkalis.* **R. Dubrisay** and **P. Picard.** (Comptes Rendus, 177. pp. 589–591, Oct. 1, 1923.)—Alkali carbonates diminish the interfacial tension between vaseline oil and water, but to a far less extent than alkali hydroxides, and the effect of bicarbonates is still less. Probably because they decrease the solubility of soap and thus favour its condensation on the surface layer, neutral salts decrease the interfacial tension between mixtures of vaseline oil with oleic acid and dilute soap solution.

T. H. P.

384. *Relation between Young's Modulus and Atomic Volume.* **A. Portevin.** (Comptes Rendus, 177. pp. 634–636, Oct. 8, 1923.)—The equation, $E = 8 \cdot 10^5 \left(\frac{\delta}{M}\right)^2$, where E is Young's modulus, δ the density, and M the atomic mass, recently given by Peczalski [Abstract 1016 (1923)], is identical with that derived by Fessenden (Chem. News, 66. p. 206, 1892), namely, $E = 78 \,.\, \frac{10^4}{V^2}$, V being the atomic volume, *i.e.* $\frac{M}{\delta}$. The latter was obeyed well for metals with moduli known at that time, but it gives low values in the case of refractory metals with high moduli, such as rhodium, tantalum, and tungsten. Better concordance is obtained by means of empirical equations of the form $E = k \,.\, \frac{T^a}{V^b}$, where T is the absolute melting-point, *a* has a value of about 1 and *b* a value of about 2. A number of other relations have been derived between the elastic coefficients, notably the modulus of compressibility or its inverse with various physical magnitudes, such as the surface tension, the coefficient of cubical expansion, and the specific heat. All such are, however, connected with the formulæ given above.

From the values given by Adams and Williamson [see Abstract 1341 (1923)] for the compressibilities of various minerals, the author calculates the corresponding values of Young's modulus. The results thus obtained agree satisfactorily with available experimental data.

T. H. P.

385. *Levels and Level Bubbles.* **S. G. Starling.** (Optical Soc., Trans. 24. 5. pp. 261–286; Disc., 286–288, 1922–1923.)—As a preliminary, determinations of the surface tension and viscosity of benzol, xylol, chloroform, and a range of petroleum ethers were made, and the results are given. The length of a bubble at various temperatures is mainly determined by the expansion of the liquid. Results of observations of the dependence are given, but no reliable formula was found to fit them. The damping of bubble swings was investigated by tilting the level and letting go. The ratio of first to second displacement was the criterion of damping used. It is found, by observing at various temperatures, that the longer the bubble, the less the damping. It is possible to make a short bubble "dead-beat," but such a bubble is not suitable for use, as it wanders too freely. It was also found that the damping varies enormously with tube diameter, for short bubbles, but little for long ones; in all cases considered there is a marked minimum in the neighbourhood of 1·4 cm. diameter. As a result of calibration experiments, irregularities of the order of 0·0001 cm. in the tube wall are detected. A method of obtaining the calibration curve photographically in a short time is described.

W. G. B.

386. *Measurement of Air Speed in Aeroplanes.* **C. J. Stewart.** (Journ. Sci. Instruments, 1. pp. 43–50, Nov., 1923.)—A brief review of the conditions to be satisfied by air-speed indicators for use on aeroplanes is given. The important speeds from the point of view of the pilot and the safety of his machine include the landing, maximum efficiency, maximum horizontal and maximum descending speeds, all of which are directly comparable for any given atmospheric density, although the speeds so indicated are not the true speeds. The author reviews the principal types of air-speed indicators, including the impact, pressure head, and the rotating surface types, with special reference to the second class. The Pitot, Venturi, and Pitot-Venturi pressure-head indicators are described more fully, and reference is made to the work which has been carried out in France and Germany in connection with double-Venturi instruments; the Bruhn indicator, on this principle, gives a differential pressure about 13·6 times that due to a simple Pitot tube. The valuable work undertaken by the United States with the object of developing a reliable Venturi-head is also emphasised, and a short account is given of satisfactory design which has been evolved. Expressing the sensitivity as the head of water necessary to produce a full-scale deflection of the indicator pointer, and assuming a speed of 120 m.p.h., the sensitivities of the Pitot type (British), Pitot-Venturi, and double-Venturi types are given as 7, 48, and 85 inches of water respectively. The paper concludes with a short account of the corrections to be applied to indicated air speed due to change of density, and a correction formula is given.

A. W. J.

387. *Glass-to-Metal Joint.* **C. H. Meyers.** (Am. Chem. Soc., J. 45. pp. 2135–2136, Sept., 1923.)—The author describes the procedure to give a satisfactory soldered joint (using tin or a solder of low melting-point) between glass and metal without platinising the glass. Both glass and metal must be very clean. The glass is cleaned with chromic acid rinsed with distilled water and dried. The metal part is coated with tin or solder and the surface of the molten tin cleaned with zinc chloride. The metal part is allowed to cool, is washed thoroughly with distilled water, and, if necessary, is scrubbed with absorbent cotton free from grease or dirt, and dried. The two parts are then held together above a flame and as soon as the tin melts, the glass is inserted into the metal without the addition of any flux. One such joint, about 5 mm. diameter, has withstood a pressure of from 60 to 70 atmospheres for three years.

T. H.

388. *The Meaning of Physical Axioms.* **A. Müller.** (Phys. Zeits. 24. pp. 444–450; Disc., 450, Oct. 15, 1923. Paper read before the Deut. Physikertag., Bonn, Sept., 1923.)—The author defines axioms as unproved fundamental propositions and discusses their significance. He sums up as follows: The physicist, whether he works experimentally or theoretically, stands in face of a nature quite independent of him, which he can question in manifold ways as to its structure, and which finally compels him to shape his axioms in this way or that. J. J. S.

389. *Fitting Probability and other Curves to Graphs of Observation.* **A. P. Trotter.** (Journ. Sci. Instruments, 1. pp. 60–61, Nov., 1923.)—A description of two jointed frames, an ordinate frame, and an abscissa frame, with a diagram showing a pair of these frames skewed and superimposed to fit a probability curve. [See Abstract **196** (1920).] T. C. H.

390. *Troublesome Systematic Error.* **F. H. Seares.** (Roy. Astron. Soc., M.N. 84. pp. 15–20, Nov., 1923.)—The systematic effect discussed by Eddington and (Miss) Douglas [see Abstract **1089** (1923)] originates in the combined influence of accidental error of observation and unequal probability in the true values of the quantity measure. If ϵ is the error of M′, the observed absolute magnitude, two equations are derived for $\bar{\epsilon}$: (1) where M follows the Gaussian frequency law, $\bar{\epsilon} = \bar{M} - \bar{M}' = -f\bar{M}'$, where $f = \epsilon_0^2/\sigma^2 = r^2/R^2$, in which ϵ_0 is the ordinary mean error of observation, σ the standard deviation of M′, and r and R the probable error and probable deviation respectively; and (2) without restriction to Gaussian frequency laws, $\bar{\epsilon} = \bar{M} - \bar{M}' = \bar{\epsilon}^2 F_2'(M')/F_2(M')$. From this last equation it appears that $\bar{\epsilon}$ depends on the slope of the frequency curve within the interval covered by the observations which are combined into a mean—the flatter the curve the smaller the error; and if the slope is reversed the error changes sign. The bearing of this on the accuracy of the progression of log T, where T is the tangential velocity, is discussed, for if giants and dwarfs are considered separately, more serious errors creep in than if the stars are all considered together.

A. S. D. M.

391. *Errors of Observation.* **R. A. Fisher.** (Cambridge Phil. Soc., Proc. 21. pp. 655–658, Nov., 1923.)—The author points out in this note that some of Burnside's conclusions [Abstract **2066** (1923)] had been anticipated by "Student" in 1908 under the title "The Probable Error of a Mean" (Biometrika, 6. pp. 1–25). "Student's" work, he states, is so fundamental theoretically, and bears so directly on the practical conclusions to be drawn from small samples, that it deserves to be far more widely known than it is at present. Attention is also called to "Student's" (Biometrika, 11. pp. 414–417, 1917) "Tables for estimating the probability that the mean of a unique sample of observations lies between $-\infty$ and any given distance of the mean of the population from which the sample is drawn." Fuller tables are in course of preparation. The slight difference between the integral tabulated by "Student" and Burnside's result is due to the latter's assumption of an *a priori* probability for the precision constant, while the former gives the actual distribution in random samples. G. W. DE T.

392. *Method of Least Squares and Curve Fitting.* **H. S. Uhler.** (Optical Soc. of America, J. and Rev. Sci. Inst. 7. pp. 1043–1066, Nov., 1923.)—The author calls attention to some errors of principle in the usual treatment of the applications of least squares in determining the constants of assumed laws for curves. Usually there are possible errors in *both* the related quantities, but as commonly given the method allows for errors in one only. In *drawing* a curve, we attempt to make it lie as evenly among the points as possible, *i.e.* to make the sum of the squares of *normal* distances as small as possible, but the common treatment makes the sum of the squares of the *vertical* distances a minimum. The problem of finding the constants X and Y so that the line $Xx + Yy = 1$ may make the sum of the squares of the weighted errors in x and y a minimum is completely solved, but for details the paper must be consulted. W. G. B.

393. *An Improved Actinograph.* **A. W. Clayden.** (Roy. Meteorolog. Soc., J. 49. pp. 231–234; Disc., 234–235, Oct., 1923.)—An instrument constructed by the author some years ago consisted of two bimetallic coils mounted about a horizontal axis. Of these coils one was blackened and exposed to the sun, while the other was bright and shaded by a cover; a pen arm was arranged to give a record of the temperature difference between the coils. The new instrument is somewhat larger, and its axis is set parallel to that of the earth to minimise variations in the angle of incidence. Generally the records show a rise in the morning and descent to the neutral line towards evening. Accurate measurements of solar radiation are not obtained, but the instrument serves to give a record of changes in cloud amount and sunshine. A. W. L.

394. *On Soaring Flight.* **N. V. Karpen.** (Comptes Rendus, 177. pp. 679–681, Oct. 15, 1923.)—Criticises G. Nordmann's recent suggestion that a bird can take advantage of the variations of horizontal wind velocity by receiving the relative wind now in front and now behind. Passing over the difficulty of flying backwards, the change of direction of relative motion would reduce this below the critical speed. It is shown that the bird *may* draw energy from the variations of horizontal wind speed, if it directs the relative velocity opposite to the acceleration of the wind, when the rate at which it can take energy from the wind is shown to be $W(va)/g$, W being its weight, v the relative velocity, and a the wind acceleration. W. G. B.

395. *Measurement of True Height by Aneroid.* **L. N. G. Filon.** (Journ. Sci. Instruments, 1. pp. 1–8, Oct., 1923.)—The ordinary aneroid records the height as calculated on the assumption of an atmosphere at a uniform temperature of 10° C. Assuming that the temperature gradient in the atmosphere is sensibly constant and expressed by $\sigma = -d\theta/dh$, at height h the temperature $\theta = \theta_1 - \sigma h$, where σ has the value $1°{\cdot}65$ C. per 1000 ft. up to 10,000 ft., or $1°{\cdot}98$ C. per 1000 ft. up to 30,000 ft., the ground temperature in the latter case being taken 5° above its actual value. The paper describes two types of dial which give a correct reading of "lapse-rate" (σ) height with considerable accuracy. A setting scale of temperature is marked on the dial, and at the start the dial is rotated until the scale mark corresponding to the ground temperature comes to the pointer. The latter then reads also the standard height of the starting point for the given day. A subsequent reading being taken at a higher level, subtraction of the first reading gives the true height. Two dials are described in which these ideas are embodied. In the second type, a double dial is used which does the subtraction mechanically. A third design involves neither approximate setting nor mental subtraction. G. E. A.

396. *A Method of Measuring the Velocity of a Current of Air.* **Huguenard.** (Comptes Rendus, 177. pp. 744–746, Oct. 22, 1923.)—The method consists in photographing the sound-wave of one electric spark by the light of another produced soon after. The amount by which the centre of the wave is displaced is thus found, and consequently the velocity of the air-current can be calculated. W. G. B.

397. *Modified McLeod Gauge.* **D. L. Hay.** (Optical Soc. of America, J. and Rev. Sci. Inst. 7. p. 1015, Nov., 1923.)—The rubber connections used in the ordinary form of McLeod gauge lead to contamination of the mercury and consequent sticking of the mercury in the capillary. In the arrangement described here, all the connections are in glass and thus the difficulty referred to is eliminated. A. A. D.

398. *A Self-Exhausting Mercury-Vapour Lamp.* **H. P. Waran.** (Journ. Sci. Instruments, 1. pp. 54–56, Nov., 1923.)—Describes a mercury-vapour lamp embodying the vacuum regenerative device previously described by the author. [See Abstract 1710 (1923).] G. A. S.

399. *Motion of a Falling Chronograph Projectile.* **L. Thompson.** (Nat. Acad. Sci., Proc. 9. pp. 329–334, Sept., 1923.)—An optical chronograph in which neither the high-velocity projectile nor that of the chronograph, the latter carrying the photographic surface upon which the record is made, strikes a material object during the experiment. In order that the change in velocity in a short section of the trajectory shall be significant for the determination of the air-resistance, it is necessary to make correction for small disturbing factors, such as the effects resulting from the influence of the holding magnet upon the early stages of the motion of the chronograph projectile, the acceleration increasing from an initial value of zero to the final value g during the breaking of the magnet circuit; and the resistance of the air in slightly retarding the falling projectile. The author gives a method for determining the magnet effect, and a table containing numerical values for ranges characteristic of chronographs as generally used. Examples are shown in the paper of the type of record obtained with the optical apparatus. T. C. H.

400. *Theory of Thermal Stress in a Long Hollow Cylinder.* **T. Matsumura.** (Kyoto Coll. Eng., Mem. 3. pp. 61–80, June, 1923. In English.)—Solves the problem of the stress in a long tube due to radial variation of temperature, taking into account the changes of modulus of elasticity and coefficient of expansion with temperature. Mathematical. W. G. B.

401. *Mechanical Determination of the Relative Rate of Two Pendulums.* **A. Guillet.** (Comptes Rendus, 177. pp. 813–815, Oct. 29, 1923.)—The difficulty in this connection is the finding of a motor which can receive a movement of uniform rotation. In a *rate comparator* constructed according to the author's plans, a movement of rotation is furnished by a chronometric motor, which has been described in the Comptes Rendus,

177. p. 741, 1923, and it is found easy to advance or retard the play of one of the contacts, since it is sufficient to turn a corresponding disc in the opposite or in the same sense as the system of toothed wheels. The manner of operation is simple and the author describes three methods, one of which requires two observers, and the others only one observer. A. S. D. M.

402. *Hydraulically Testing Gas Cylinders.* **C. Guidi.** (Accad. Sci. Torino, Atti, 58. 4–5. pp. 79–88, 1922–1923.)—The mathematics of the subject. Practical measurements. A. D.

403. *Influence of Shearing Force on the Deformation of Bent Prisms.* **O. Sesini.** (Accad. Sci. Torino, Atti, 58. 9. pp. 201–210, 1922–1923.)—Part of the displacements in a prismatic elastic solid of isotropic material subjected to bending are due to shearing forces. In practical treatises on the science of structures these are calculated by means of approximate formulæ which lead to results differing considerably from those arrived at by more rigorous calculations, such as those of Saint-Venant, given in treatises on the theory of elasticity. At first sight the first mentioned methods would appear to give a very low degree of approximation, but the author discusses various cases of deflection which occur in practice, and gives different methods of calculation, showing that when real conditions are taken into account the methods used in technical mechanics are much more worthy of attention than might be supposed. In cases for which the details of calculation are given the results differ but little from those attained by rigorous investigation. J. J. S.

404. *The Principle of Minimum Energy and the Motion of Fluids.* **W. Hovgaard.** (Nat. Acad. Sci., Proc. 9. pp. 363–369, Nov., 1923.)—It is shown that for any fluid motion, if the condition of minimum kinetic energy is fulfilled, (1) it must be regulated by a velocity potential, and consequently be irrotational, (2) the fluid must be perfect, (3) the equation of continuity must be satisfied, and (4) the boundary conditions must be satisfied. By retracing the steps of the proof, it is seen that in an incompressible, perfect fluid, subject to no chemical or thermal changes, filling completely the space between impenetrable but movable boundaries, all the conditions for minimum energy are satisfied. W. G. B.

405. *The Entrainment of Air by a Jet of Gas.* **J. S. G. Thomas** and **E. V. Evans.** (Phil. Mag. 46. pp. 785–801, Nov., 1923.)—Continues previous work [Abstract 258 (1923)] by considering the dependence of the entrainment of air upon the densities of the issuing gas and the air. Similar apparatus is used, and the various portions are jacketed so as to be able to vary the temperatures of the gases and the air. Air, CO_2, H_2, and coal gas were used in the jets. For air issuing into air of the same density, the volume, V, of air (reduced to N.T.P.) entrained per unit volume (measured under experimental conditions of temperature and pressure) of issuing gas, is proportional to the density of the issuing gas. With a denser gas in the jet, the "aeration" is less than given by this rule; with a lighter gas, more. Theoretical reasoning leads to the formula $V = \alpha\{\rho_1 + \beta(\rho_2 - \rho_1)\sqrt{\rho_1/\rho_2}\}$ α and β being constants (probably instrumental), ρ_1 the density of the gas in the jet, ρ_2 that of the air. This is in good agreement with the experiments when $\rho_2 > \rho_1$, but when $\rho_2 < \rho_1$ the empirical formula $V = a\{\rho_1 - (0 \cdot 65\rho_1\rho_2 + 0 \cdot 38)\}$ is a better fit.

W. G. B.

406. *Analytical Representation of Discontinuous Quantities.* **L. Laboccetta.** (N. Cimento, 25. pp. 231–256, May–June, 1923.)—Entirely mathematical.

A. Wh.

407. *Angle as a Fourth Fundamental Dimensional Quantity.* **A. Bartorelli.** (N. Cimento, 25. pp. 257–266, May–June, 1923.)—Generally we can write a dimensional equation $[U] = [L]^\alpha [M]^\beta [T]^\gamma$ or, in the other units, $[U_1] = [L_1]^\alpha [M_1]^\beta [T_1]^\gamma$. Then always $[U]/[U_1] = [L]^\alpha [M]^\beta [T]^\gamma/[L_1]^\alpha [M_1]^\beta [T_1]^\gamma = [L/L_1]^\alpha [M/M]^\beta [T/T]_1{}^\gamma$. Now considering angular velocity, this is defined as angle/time. Thus if we change the units of angle from A to A_1 keeping the unit of time constant, the unit of angular velocity alters also from W to W_1. But the dimensions of angular velocity are $[T]^{-1}$ and this fact necessitates the relation $[W_1/W] = [T/T]^{-1} = 1$ and hence $[W] = [W_1]$, contrary to our supposition. To avoid this difficulty, the author introduces angle [A] as an independent fundamental derived quantity writing generally $[U] = [L]^\alpha [M]^\beta [T]^\gamma [A]^\delta$ and proposes the use of the c.g.s.r. (centimetre, gramme, second, radian) system of units. It is pointed out that the length of a circular arc has not the dimensions of a simple length, but is given by $[\widehat{L}] = [L][A]$. Angular velocity is $[W] = [A][T]^{-1}$. Hence angular acceleration will be $[\phi] = [A][T]^{-2}$. Velocity in the arc of a circle is $[\widehat{V}] = [L][W]$ and also $= [\widehat{L}][T]^{-1}$. Thus the tangential acceleration $[\widehat{\phi}] = [\widehat{V}][T]^{-1} = [L][A][T^{-2}]$ and hence $[\widehat{\phi}] = [L][\phi]$. Other quantities are derived and considered.

A. Wh.

408. *Applicability of Ehrenfest's Principle.* **E. Fermi.** (N. Cimento, 25. pp. 271–285, May–June, 1923.)—By considering the surfaces of equal energy in a space of $2f$ dimensions, the coordinates representing at any instant the f position and f velocity components, the author discusses the applicability of Ehrenfest's adiabatic principle to mechanical systems of which the sole "characteristic" is shown to be the energy. In a mathematical discussion it is shown that in such systems the value of the energy at the end of an adiabatic transformation does not entirely depend on the intermediate mechanism of the transformation. Also in general it is not possible to apply Ehrenfest's principle to systems with more than one "characteristic." A. Wh.

409. *The Resistance Experienced by a Fluid in Turbulent Motion.* **J. M. Burgers.** (K. Akad. Amsterdam, Proc. 26. 7–8. pp. 582–604, 1923.)—An attempt to find an upper limit to the resistance of a fluid in turbulent motion. An idealised model of turbulence is considered, the turbulence being represented by a distribution of elliptic vortices. Two laws of distribution are examined in detail, and in one of them the resistance comes out proportional to the square of the velocity, but much greater than has been found experimentally. The other leads to a resistance coefficient proportional to $R^{-\frac{1}{2}}$, R being Reynolds' number, and gives values below the experimental ones. The paper is mainly mathematical.

W. G. B.

410. *Students' Measurements.* **F. Palmer, Jr.** (Optical Soc. of America, J. and Rev. Sci. Inst. 7. pp. 873–887, Oct., 1923.)—Simplified methods for ready approximate measurements of the number of molecules in a cub. cm. of a gas and the mass of an atom, the ratio e/m, and the electronic charge e. A. D.

411. *X-Rays and Crystal Symmetry.* **T. V. Barker.** (Nature, 112. pp. 502–505, Oct. 6, 1923.)—The study of a surface of a crystal leads to the assumption of a definite symmetry. When all known determinants have been considered, the symmetry of the crystal subject to them is of the lowest order which can be deduced from any combination of them. Hence if any determinants be ignored, a symmetry will result higher than that which would be adopted by a more comprehensive analysis. An important case arises from X-ray analysis when the symmetry is regarded as atomic. Undoubtedly the true symmetry is rather molecular, and on these lines may be explained the difference between symmetries indicated by X-ray analysis and the study of crystal surfaces. An attempt to bridge the gap by appealing to valencies involving more than one electron is defeated by the case of sal-ammoniac, and no satisfactory explanation of this can be offered. A. Wh.

412. *Determination of Structure by Means of X-Rays.* **M. Polányi.** (Phys. Zeits. 24. pp. 407–415, Oct. 1, 1923. Paper read before the Deut. Physikertag., Sept., 1923.)—Contains a condensed account of the relations involved, with special reference to the layer line method of X-ray analysis, as employed by the author and others. H. N. A.

413. *The Structure of Crystals of $NaBrO_3$ and $NaClO_3$.* **L. Vegard.** (Zeits. f. Physik, 18. 6. pp. 379–381, 1923.)—Replies to the criticism of Kolkmeijer, Bijvoet and Karssen [Abstract 1754 (1923)] on the author's results for these salts [Abstract 1039 (1923)]. Taking into account the coincidence of the α-reflection of the 200, 311, and 421 planes with the β-reflection of the 210, 321, and 431 planes, the author finds that the corrected intensities agree better with his calculated intensities than before, for the 311 and 421 lines, and that only for the 200 line is the effect of correction in the unfavourable direction, so that he still considers that there is good agreement between the observed and calculated distribution of intensity. He maintains his criticism with respect to the first line 110; comparing the intensity with that obtained in the case of $Pb(NO_3)_2$ and $Ba(NO_3)_2$. He calls attention to the fact that in his comparison of intensities he has included lines up to $\sum h^2 = 41$, while Messrs. K. B. and K. have only calculated up to $\sum h^2 = 26$. His model shows a simple atomic grouping, which satisfies the volume conditions well; and he seems to claim that the experience he has gained, in using his apparatus with simpler crystals, has given a possibility of obtaining accuracy in judging more complicated structures. H. N. A.

414. *Crystal Interference in Spectrally Analysed Röntgen Light and its Application to the Determination of the Crystal Lattice.* **R. Schachenmeier.** (Zeits. f. Physik, 19. 2. pp. 94–111, 1923.)—In this paper a detailed description is given of an experimental arrangement for producing a new species of Röntgen-ray interference in crystals. Following this comes an exposition of the theory of such interference and an extension of the results obtained to the determination of the crystal lattice. Further applications are tentatively discussed for the evaluation of atomic distance and the angle in the crystal lattice, while extension to fluorescence wavelengths and absorption limits of an atom are foreshadowed. The paper is a combination of mathematical and experimental detail. H. H. Ho.

415. *The Quantum Integral and Diffraction by a Crystal.* **A. H. Compton.** (Nat. Acad. Sci. Proc. 9. pp. 359–362, Nov., 1923.)—Duane has shown [Abstract 2430 (1923)] that if the momentum of a crystal grating perpendicular to the crystal face be nh/a, where n is an integer, h is Planck's constant and a is the distance between successive atomic layers, and if the momentum of the incident radiation quantum be $h\nu/c$, then Bragg's diffraction formula $n\lambda = 2a \sin\theta$ is a necessary consequence. The author shows that the general statement of the quantum postulate, $\int p dq = nh + \eta$, leads directly to the result that the momentum of the crystal changes by integral multiples of h/a, as Duane assumes. A. D.

416. *The Spectroscopic Investigation of Atomic Structure.* **F. Paschen.** (Phys. Zeits. 24. pp. 401–407, Oct. 1, 1923. Paper read before the Deut. Physikertag., Bonn, Sept., 1923.)—A clear general account of the present position and recent work with respect to the application of quantum relations to spectroscopic investigations. The fundamental ideas of quantum energy levels and their relation to spectral terms and the combination principle of Ritz are discussed and the general ideas due to Bohr, with the fine structure theory due to Sommerfeld, are briefly summarised, accounts being given of the origin of various lines corresponding to different values of both quantum numbers. The effects of electric and magnetic fields on the emission spectra of the elements are discussed together with the recent work of Landé in extending the laws of doublets to quartets, sextets, etc. The fundamental opposition to classical mechanics and electrodynamics is noted and the importance of Bohr's suggestions emphasised. W. V. M.

417. *The Relation between the Spectra and the Sizes of the Alkali Metal Atoms.* **L. A. Turner.** (Astrophys. J. 58. pp. 176–194, Oct., 1923.) —A theory is developed which gives the relation between the energies and quantum numbers of orbits of the valency electrons in atoms differing in size but geometrically similar. It is shown that the wave numbers for some of the outer orbits of the four alkali metal atoms Na, K, Rb, Cs are in fair agreement with the assumption that the structure beneath the valency electron, or kernel, is geometrically similar but different in size for the four atoms. The relative sizes of these kernels obtained by this method agree with results obtained by other methods in the case of various orbits, such as the circular ones connected with the 3*d* and 4*b* terms, with azimuthal quantum numbers 3 and 4 respectively and radial quantum numbers 0. The quantum numbers for these *p*, *d*, and *b* terms as given by Bohr in his new theory give the best agreement with this theory of geometrical similarity.

An expression is obtained for the maximum radius of a valency electron in terms of wave number, azimuthal quantum number, strength of the field of the kernel at the outermost point of the orbit, and known constants. For circular orbits, such as the 3*d*- and 4*b*-orbits the field-strengths and radii are calculated. These results combined with the size ratios of the kernels give curves for the variation of the field-strength as a function of the radius, for the four atoms. Fues has shown that the spectrum of Na can be accounted for by assuming that the electron orbits are in a central field of force which varies with distance from the centre in approximately the same way as the field about a central nucleus of charge $+qe$ surrounded by eight electrons at the corners of a cube, varies along a radius perpendicular to a cube face. An assumption of geometrical similarity of the field about the kernel is a fair approximation for K, Rb, and Cs, but not for Na. The radii of the normal atoms are calculated, and it is concluded these atoms must be present in the space lattice of the metals as positive ions, the electrons fitting into the structure between the ions. The results show that kernel is much smaller for any alkaline-earth metal atom than for the corresponding alkali metal atom.

W. V. M.

418. *Electrical Moments of Atoms and Molecules.* **R. D. Kleeman.** (Frank. Inst., J. 196. pp. 479–493, Oct., 1923.)—From latent heat considerations are developed expressions giving the effective electrical moments of atoms and molecules. The process involves extrapolation of the latent heat expression used to the absolute zero, and the assumptions made are that molecules behave as definite doublets in their interactions and that the moments of these doublets are independent of the density of the substance throughout its changes of state. The final result is reached that the moment of an atom is proportional to $N^{2/3}$ where N is the atomic number and of a molecule to $\sum N^{2/3}$. In the case of hydrogen, the effective distance between the charges appears to be of the order of 1/25th of the radius given by Bohr for the radius of the orbit of the rotating electron. It is suggested that this is due to the central positive charge lying out of the plane of rotation of the electron. An elliptic orbit might also account for this effect. The Clausius-Mossotti expression for the dielectric constant is then combined with these values an information obtained as to the effect of temperature on the alinement of the doublets in an electric field. Hence it is shown that the internal specific heat per gramme-molecule, C, is related to the atomic numbers, N, and atomic masses, a, according to a relation $\log C \propto \sum N^{2/3} \propto \sum a^{1/2}$. A. Wh.

419. *The Radii of the Alkali and Halogen Ions and of the Atoms of Inert Gases.* **W. P. Davey.** (Phys. Rev. 22. pp. 211–220, Sept., 1923.)—This paper deals first with the packing radii of the alkali and halogen ions in crystal lattices, previous work [see Abstract 1032 (1923)] being also summarised for convenience. An analysis of recent results for the distances of closest approach of the ions in the lattices of all the alkali halides indicates (1) that these ions pack as though they were nearly spherical in shape ; (2) that the heavier ions have packing radii which are nearly constant, *i.e.* independent of the ions with which they are combined ; and (3) that the radii of K^+, Rb^+, and Cs^+ are approximately equal to those of the negative ions with the same number of electrons, Cl^-, Br^-, and I^-, respectively, the approximation being closer the greater the atomic number. Assuming the radii of Cs^+ and I^- to be equal, and that the first two conclusions above hold rigidly, the radii of the ions are computed to be as follows, in units of 10^{-8} cm. : for Cs^+ and I^-, 1·974 ; Rb^+, 1·679 ; Br^-, 1·737 ; K^+, 1·548 ; Cl^-, 1·589 ; Na^+, 1·1 to 1·2 ; Fl^-, 1·0 to 1·2. These values are in general agreement with the average of the ionic radii computed by Landé (from crystal data), Richards (from compressibility), and Saha (from ionisation potentials), but differ considerably from Bragg's results from X-ray data. The above conclusions are shown to be in qualitative agreement with the Lewis-Langmuir theory. The packing radii of the inert gases are next dealt with. These have been computed from X-ray data on the assumption that for each gas the radius is the mean of those for the alkali and halogen ions with the same number of electrons: Xe, 1·97; Kr, 1·71; Ar, 1·57; Ne, 1·15. These are only from 0·0 to 0·27 units higher than the values obtained by Rankine from viscosity measurements. Assuming these radii, the atomic volume per electron comes out approximately constant for Xe, Kr, and Ne, though somewhat low for Ar. H. H. Ho.

420. *The Quantitative Relation Between the Intermittent Alterations of Atoms and the Harmonic Components of their Mass Changes.* **K. Fehrle.** (Zeits. f. Physik, 19. 2. pp. 128–135, 1923.)—In a previous paper [see Abstract 2445 (1923)] the author showed that the intermittent alteration of atoms at the end of the periodic system of chemical elements and its explanation in an increasing displacement in the potential series proceeding from two points up to the end of the periodic system. The present paper examines this problem more rigidly, and establishes the connection between the change of mass and the displacement. It is mathematical throughout. H. H. Ho.

421. *The Quantum Theory of the Hydrogen Molecule.* **L. Nordheim.** (Zeits. f. Physik, 19. 2. pp. 69–93, 1923.)—Previous work on the hydrogen molecule is first discussed, including that of Franck and his co-workers on electronic impact [see Abstract 1387 (1923)]. The author now investigates certain adiabatic proposals of Born (Naturw. 10. 677, 1922), but concludes that no satisfactory model of the hydrogen molecule can be derived on adiabatic grounds. He uses for this purpose the disturbance method of Born and Pauli, together with certain hypotheses on degenerated systems by Born and Heisenberg. The following conception is asserted to be possible: The atoms when greatly removed from each other take up a certain configuration worked out in the paper, whereby attraction prevails; on approach, the type of motion changes irreversibly into an orbit type in which the union of the nuclei is much firmer than previously. In consequence the nuclei are unable to separate completely again, but form a molecule with regulated nuclear oscillations whose total energy is certainly not less than that of the sum of the separate systems, though dynamically stable. The energy of the nucleus oscillation can be altered later through impact or radiation. H. H. Ho.

422. *An Application of the Adiabatic Hypothesis to the Ortho Helium Model.* **O. Halpern.** (Zeits. f. Physik, 18. 6. pp. 344–351, 1923.)—The problem of the helium model is of great interest because of its being the simplest atom after hydrogen, and also because of the existence of two spectral series, ortho and para, which afford no mutual combinations. Landé has ascribed a coplanar electronic system to the ortho-helium spectrum and one with crossed plane orbits to the parhelium, the normal state of helium being the latter. Landé's work has been extended by Bohr, Kramers, and van Vleck [see Abstract 1751 (1923)], by means of the adiabatic hypothesis. The Bohr view based on Kramer's calculations

for parhelium limited the validity of mechanics in systems with several electrons to cases of adiabatic construction. Adopting this standpoint there is found to be a complete absence of agreement between the observed and calculated spectral terms of ortho helium. This lack of accord has now been established by the present author as due to the fact that the adiabatic treatment cannot be applied to coplanar electronic systems.
H. H. Ho.

423. *Possible Mechanics of the Hydrogen Atom.* **W. M. H. Greaves.** (Cambridge Phil. Soc., Proc. 21. pp. 600–609, Nov., 1923.)—The author considers the possiblity of explaining the existence of a discrete series of stable orbits in the hydrogen atom on the assumption that the electron moves according to the laws of classical dynamics, under the influence of certain radial and transverse forces. With the help of a few simplifying hypotheses forces are found which would in fact account for the effects required by the Bohr theory. Their expressions are rather complicated and the author emphasises the fact that his object is simply to show the conclusions which must follow if classical dynamics is retained, so that material may be available for deciding whether or not this retention is plausible.
M. H. A. N.

424. *Partitioning of Space into Enantiomorphous Polyhedra.* **W. Barlow.** (Phil. Mag. 46. pp. 930–956, Nov., 1923. Zeits. f. Kristallographie, 58. pp. 605–628.)—In 1914 the author indicated the possibility of a partitioning of space into space-filling, similar, polyhedral cells, each having 13 plane faces; and in the present paper he gives full details as to the methods employed, illustrated by models and diagrams, with full geometrical details. The cells are enantiomorphous polyhedra, the two enantiomorphous kinds of cell being equally numerous, and similarly distributed. One face of each cell is a regular hexagon, which is common to two enantiomorphously related cells, the centre of this face being a centre of symmetry. Each angular point of a hexagonal interface is common to four cells. A "*mat*" is constructed, showing the faces of a cell, as they would be related if, while remaining attached at single edges, they were hinged and spread out in the same plane; there are three kinds of interfaces, a hexagonal, a quadrilateral, and a five-sided. By means of the "*mat*," cardboard models can be constructed of the cells, the two kinds being obtained by folding the cardboard in opposite directions. The models can be built together, so as to fill up the whole of the space, the two kinds of cell being mirror images of one another. The author has called attention to the applicability of the space-partitioning in question to the case of a crystal of potassium chloride, the symmetry of which is regarded as hemihedral cubic. The artificial system presents, however, if the allotment to the same kind of atom is uniform throughout, a lower class of symmetry than that assigned to the crystal, *viz.* tetartohedry not hemihedry. This discrepancy may be attributed to intimate twinning, which is capable of closely mimicking the higher class of symmetry. The foregoing is a particular case of an infinite series of partitionings, each of which is based on some regular point-system, the points of which form pairs, the two individual points of a pair lying within the same cubic cell of a half system of cubic cells, throughout which the cubes are in contact at edges only, and being found on the same trigonal axis, equidistant from the cell centre.
H. N. A.

425. *Gravitation and Inertia.* **F. Riedinger.** (Zeits. f. Physik, 19. 1. pp. 43–46, 1923.)—A discussion of the question how we may reconcile the known fact (Richarz and Krigar-Menzel) that in an isolated chamber (a Spandau casemate) two weights at the same level may be adjusted so as to balance one another, but will fail to do so if the one of them be lowered by two metres, with Einstein's conception of the impossibility of determining whether there is a gravitation field or an accelerated motion. A. D.

426. *The Generalised Relativistic Quantum Conditions.* **O. W. Richardson.** (Phil. Mag. 46. pp. 911–914, Nov., 1923.)—The generalisation suggested by W. Wilson [Abstract 1630 (1923)] of the third postulate of the quantum theory, the addition of which he had previously suggested to Bohr's two postulates, for a charged particle executing a periodic motive, was expressible in the form $\int(p_s+eA_s)dq_s=n_sh(s=1, 2, 3, 4) \ldots (1)$, where p_s and q_s are the Hamiltonian coordinates, e is the charge, A the four-vector potential, h Planck's constant, and the n_s integral numbers, the integrals in each case extending over the period of the corresponding q. The fourth of these equations was not discussed in Wilson's paper, but he has pointed out in conversation with the author that it is expressible in the simple form: $\int(T + V)dt = n_4h$, where T is the kinetic and V the potential energy of the particle, and t the real time, as is easily verified. There are important types of motion for which the first three members of (1) reduce to the single equation $\int pdq = nh \ldots (3)$. If also the energy is constant then; for a Planck oscillator, $\int Tdt = \int Vdt$, and it will be subject to (3) if, and only if, $n_4 = -n$; for a simple Bohr atom, (3) will be fulfilled only if $n_4 = \pm n/2$; both as in the non-relativistic case. The author points out that, by means of a theorem due to Jacobi, Sommerfeld ("Atomic Structure and Spectral Lines," p. 548), shows that for small speeds compared with that of light these results can be generalised to include the case of central forces varying as r^μ, where r is the distance, into the formula $n_4 = -n(\mu + 3)/2(\mu + 1)$, and gives a table of values of n_4 in terms of n for different values of μ. It seems to him possible that the fractional relations arising with the less usual laws of force may be connected with the complex Zeeman effects which seem symptomatic in intra-atomic fields of complex types. Since T + V is constant there is no mathematical periodicity in these motions, but only a periodicity in the physical properties of the energy. An alternative suggested by Wilson would be to use the fourth relation to define an additional frequency. G. W. DE T.

427. *The Symmetric Potentials Leading to Longitudinal Solutions of Einstein's Equations.* **A. Palatini.** (N. Cimento, 26. pp. 5–24, July–Aug.–Sept., 1923.)—A development of Levi-Cività's well-known papers: "ds^2 of Einstein in Newtonian fields" (1917–1919). In those papers it was shown that a correspondence can be set up between the Einstein "potential" (roughly the reciprocal of the coefficient of dr^2), in certain statical solutions called "longitudinal," and the Newtonian potential due to distributions of gravitating matter. For example, the Schwarzschild solution corresponds to a surface density on a prolate spheroid. In the present paper it is first shown that Levi-Cività's solutions are contained in a more general class proposed by Weyl: and the Weyl solution corresponding to a Newtonian surface distribution on two prolate spheroids with a common axis of symmetry is determined. This is interpreted as giving the field equations due to two fixed massive particles. M. H. A. N.

428. *On the Lorentz and Galilei Transformation.* **N. v. Raschevsky.** (Zeits. f. Physik, 20. 2. pp. 129–131, 1923.)—In a previous paper [see Abstract 1529 (1923)] the author has discussed the work of Guillaume on the compatibility of the Lorentz and Galilei transformation, against which the following objection was raised: It is not possible that by the use of different time parameters the relative velocity of 2 systems retains the same value v, since in one case the true velocity is concerned which is given by dx/dt, and in the other the apparent velocity expressed as $dx/d\tau$. The author now states that although this objection is generally valid, yet for the case treated by Guillaume it is by no means so and he now shows that by his own treatment of the problem the result obtained is identical with that by Guillaume. H. H. Ho.

429. *Relativity.* **E. Persico.** (Accad. Lincei, Atti, 32. ii. pp. 208–211, Oct., 1923.)—Of the two fundamental differential quadratics which appear in the theory of surfaces, the one (the linear element) has a known physical interpretation in the theory of relativity; the other (the surface considered in reference to the surrounding space) has not yet been considered in that theory. The author shows that while the former leads to geometrical relations of space, the latter leads (when the surrounding medium is a space-time) to optical relations. A. D.

430. *The Michelson and Morley Experiment.* **E. Brylinski.** (Comptes Rendus, 177. pp. 874–876, Nov. 5, and pp. 1023–1025, Nov. 19, 1923.)—With a velocity parallel to the light and a semi-translucent-mirror angle of 45°, interference-fringes are not to be looked for. If we assume the negative result of the M and M experiment to be due to a contraction, this contraction is not in the ratio 1 to $\sqrt{1-\beta^2}$ but in the ratio 1 to $\sqrt{1-\beta^2-\beta^3+\beta^5}$ for the first orientation and in another ratio, also involving odd powers of β, for the second orientation. Therefore there cannot be any such real contraction; and besides, the presence of odd powers of β leads to inadmissible discrepancies. There is an infinity of solutions for the assumed contraction. A. D.

431. *Newton's Law and its Metrics.* **F. Kottler.** (Akad. Wiss. Wien, Ber. 131. 2a. No. 1. pp. 1–14, 1922.)—The author's objective in this paper is to show that the assumption, commonly made by astronomers, that there is a necessary connection between Newton's law of attraction and the geometry of our space, is quite unwarranted. He shows that, on the contrary, Newton's gravitation theory is to be regarded as being as free from *à priori* metrical limitations as the modern physics of fields. A clear distinction must be drawn between forces and force fluxes, the latter are given independent of metrics, and are not, as such, subject to measurement. Only the mechanical working of the fields can be measured, that is to say, the forces. This is effected through the concept of work, which is therefore the source of the metric. It will be seen, therefore, that there is no manner of relation between purely physical fields and the metrics of our space. It follows from observation that the latter are either exactly or approximately Euclidean. And this is as far as our powers of observation and experiment will carry us. The author's argument is simply and clearly developed. It is, however, with the exception of par. 1, in which the views of Kant, Laplace and others are referred to, entirely mathematical. G. W. DE T.

432. *Maxwell's Equations and Metrics.* **F. Kottler.** (Akad. Wiss, Wien, Ber. 131. 2a. No. 2. pp. 119–146, 1922.)—It is shown by a very similar line of argument to that employed in the author's paper on Newton's law and its metrics [see preceding abstract], that in Maxwell's electrodynamics also purely physical fields are free from the limitations of any metric. In the present case, however, the field is defined by two six-vectors in the four-dimensional Minkowski time-space. Both of these are independent of any metric. The metrics are not here introduced, as was the case in Newtonian mechanics, through dynamical (energetic) points of view, for the field determines its own electrodynamics. The metrics are introduced from kinematic points of view, namely, through the laws of propagation of the field, in other words optical laws. They are determined by the relations between the field vectors expressed in terms of the dielectric capacity and the permeability. In these, therefore, lies the source of the metrics of Maxwellian electrodynamics, and therefore of the Lorentz-Minkowski-Einstein relativity theory. But the field constants appear as unknown functions of the time-space coordinates, which we attempt to determine by mechanical assistance, such as the properties of rigid bodies, which would provide a metric resting on mechanical foundations if matter were independent of electricity, which it is not, and mechanics consequently are made to depend on optical laws. Again, in Einstein's general relativity theory the field is derived from the metrics, whereas the author assumes that the field is independent of the metric. Suppose Einstein's theory accepted as experimentally justified. Then, as before, the field is made to depend on optical laws. This inversion is the fundamental concept of the explanation of gravitation by Einstein's general relativity theory. In either case the field would be adequately defined as a secondary product of light. G W. DE T.

433. *Einstein Effects in Solar Spectrum.* **J. Evershed.** (Observatory, 46. pp. 299–304, Oct., 1923.)—A summary of this research at Kodaikanal. The gravitational effect should be the same in all spectra, for all positions on the sun, proportional to wave-length, increasing towards the red, and equivalent to a motion of recession of 0·634 km./sec. This should be easily measurable. The author stresses the absence of pressure effects in the sun so that metallic lines should serve as well as cyanogen. High-level iron lines in the ultra-violet indicate an excessive shift, especially at the limb, and this, with an apparent variation, suggests a motion varying possibly with the sunspot period, and superposed on the gravitational effect, involving a tangential movement of recession at all parts of the limb—in other words, an earth effect. But the weaker, or low-level iron lines and the sodium D-lines appear constant, and there is in these a reasonably close agreement between the observed and predicted shifts. The final evidence given by the light reflected from Venus has been that this is displaced to the red, as in ordinary sunlight. A. S. D. M.

434. *Einstein Data.* **C. Burali-Forti.** (Accad. Sci. Torino, Atti, 58. 4–5. pp. 95–97, 1922–1923.)—The author is in doubt as to the conclusiveness of the Einstein crucial tests, because (*a*) the bend of stellar rays passing the sun conforms too closely to the results of calculation, without providing for refraction by the photosphere; and (*b*) because the 42″ in the perihelium of Mercury exactly fills up the gap between 574″ and 532″, but the 532″ has been taken over from Newtonian calculations and may not be an applicable figure on Einsteinian principles. A. D.

435. *First and Second Order Effects in Einstein's Theory.* **A. Bokowski.** (Zeits. f. Physik, 18. 3-4. pp. 217–227, 1923.)—The author's aim is to obtain successive approximations to the equations of motion in a gravitational field without the use of general invariant theory. In this paper the first small terms, sufficient to account for the motion of Mercury's perihelion and the bending of light are obtained. It is assumed that the paths are geodesics in a manifold in which the g_{ik} can be expanded in powers of a parameter α, and are such that $g = -1 + O(\alpha^2)$; further, that certain conditions respecting symmetry and character at infinity are fulfilled, and that $d\sigma^2 (= g_{ik} dx_i dx_k$ summed over 1, 2, 3 only) is an *orthogonal* invariant. From these postulates, with the help of a theorem on possible orthogonal, invariants, the values $g_{ik} = \delta_{ik} + \alpha x_i x_k / r^3$, $(i, k = 1, 2, 3)$, $g_{4k} = 0$; $g_{44} = \delta_{44} - \alpha / r$ are reached, in agreement with the Schwarzschild solution when α^2 is neglected.

The author asserts that his postulates are compatible with the general principle of relativity in the sense laid down by Klein in his "Erlanger Programm" for geometrical researches. M. H. A. N.

METEOROLOGY AND GEO-PHYSICS.

436. *Units and Constants in Aerography.* **A. McAdie.** (Astron. Obs. of Harvard College Annals. 86. Part 2. pp. 95–106, 1922.)—A general discussion. Reference is made to suggestions by G. N. Lewis. In 1920 E. Q. Adams published a paper on "A More Nearly Rational System of Units" ("Science," 1920, p. 525). He brought conflicting systems into harmony by a suitable selection of the unit of mass, by making the numerical value of the velocity of light a power of 10, and by using the Heaviside definition of unit charge. A corrected list of the units and their values in C.G.S. and engineering units by Adams is here given. W. R. C.

437. *Observations made Twice Daily in 1922 at the Blue Hill Meteorological Observatory.* (Astron. Obs. of Harvard College Annals. 86. Part 2. pp. 71–94, 1922.)

438. *Accuracy of Areal Rainfall Estimates.* **R. E. Horton.** (Monthly Weather Rev. 51. pp. 348–353, July, 1923.)—A study of records of rainfall for 42 stations in the Derwent Basin shows that fair accuracy is obtained when the mean rainfall over a small area is determined from a single station, provided that station lies within the area. The average and maximum errors of the arithmetic means of areal rainfall are inversely proportional to the number of stations employed and directly proportional to the range ratio (*i.e.* the percentage ratio of the range to the approximate areal mean); the average error is usually about a quarter of the maximum error. The arithmetic mean and the Thiessen methods give identical results, either for a single station or for a large number of stations; for a limited number of stations the maximum error is slightly less by the Thiessen method. For very small areas an accuracy of within 2 % can generally be obtained if a station exists in the area. A. W. L.

439. *The Relation between the Duration, Intensity, and Periodicity of Rainfall.* **P. Gorbatchev.** (Monthly Weather Rev. **51.** pp. 305–308; Disc., 308–309, June, 1923.)—If h is the amount of precipitation which can be produced from a cloud in time t, the average intensity of precipitation, i, is h/t. The rain power, Δ, depends on the total amount and intensity of the rainfall according to the equation, $\Delta = \sqrt{hi} = i\sqrt{t}$. This equation shows that if the value of Δ is known for a particular station the maximum intensities for various durations may be calculated. The rain-power is of use in the classification of rains, comparisons of different rains, and also gives a method of testing doubtful observations. It has been found that the limiting rain-power varies in different years and a period of 35 or 70 years is suggested for these variations.

Examination of the number of rains exceeding a given rain-power gives a definite regularity from which, ρ, the period for only one exceeding the given power, may be determined. Plotting Δ against ρ shows that $\Delta = \mu\sqrt[3]{\rho}$, in which μ is a constant climatic factor for the country. From this equation the recurrence of rain of different powers, average yearly amounts of precipitation and the largest rain-powers justified by observation may be deduced. It is pointed out in the *discussion* by **H. R. Leach** and **R. E. Horton** that the rain-power formula $\Delta = i\sqrt{t}$, does not agree accurately with the most recent intensity-duration formulæ, but it may be used as an approximation in short storms. A. W L.

440. *Rainfall Interpolation.* **R. E. Horton.** (Monthly Weather Rev. **51.** pp. 291–304, June, 1923.)—Examples worked out by various methods for the interpolation of rainfall show that the methods using records from surrounding stations give smaller arithmetic errors than those using data for the interpolation station only; the magnitude of the algebraic errors is approximately the same in each case. The most accurate results are obtained if the data for both the interpolation station and for surrounding stations are employed; the simplest methods for use in regions of low or moderate rainfall are the direct three-station average and the inclined plane method. For regions of high rainfall the errors are least if methods employing Fournie ratios and normals are used, but it is less laborious to use contemporaneous records by means of weighed correction ratios. A. W. L.

441. *Trajectories of Storms.* **A. Baldit.** (Comptes Rendus, **177.** pp. 773–776, Oct. 22, 1923.)—A study of the paths followed by storm centres shows that a storm may divide into two smaller ones, which travel in different directions. Such cases may be classified as due solely to geographical features, or as caused by the travel of the storm. They may be caused by the passage of a line-squall over a region where conditions are favourable for the genesis of storms. A typical case, studied in detail, is that of a storm in the Higher Loire on June 22, 1922. A. W. L.

442. *The Colour of Clouds.* **P. Villard.** (Comptes Rendus, 177. pp. 515–518, Sept. 17, 1923.)—In certain cases the colour of clouds may differ from that of the light which illuminates them. It has been observed that small detached white cumuli, illuminated with white light, may become grey during evaporation and even stand out in black against a clear sky; if condensation occurs the clouds reappear and the colour changes take place in the reverse order. Such changes often occur in the small patches of cumulus found when the wind veers from W. towards N. after unsettled weather; they are rarer, or less definite, in misty weather with S.E. winds. They have not been observed in clouds composed of ice particles. A. W. L.

443. *The Upper Atmosphere.* **J. Satterly.** (Roy. Astron. Soc. Canada, J. 17. pp. 291–301, Sept., 1923.)—A summary of Lindemann and Dobson's paper "A Theory of Meteors and the Density and Temperature of the Outer Atmosphere" [Abstract 1069 (1923)]. A. W. L.

444. *The Audibility of the Aurora.* **C. A. Chant.** (Roy. Astron. Soc. Canada, J. 17. pp. 273–284, Sept., 1923.)—Further evidence concerning the audibility of the aurora has been collected from which it is concluded that in certain cases a definite sound is emitted; this seems to occur during brilliant displays in which there is a lively motion. Several observers have stated that the auroral display and sound are simultaneous, consequently the sound cannot originate in the region of the streamers. It is suggested that the rapid motion of the aurora causes violent changes in the electrification of the air which spread to a considerable distance and give rise to something similar to a brush discharge near the earth's surface. A. W. L.

445. *The "Sama State."* **E. Gehrcke.** (Zeits. f. Physik, 19. 1. pp. 67–68, 1923.)—Refers to a paper by R. v. Dallwitz-Wegener [Abstract 1785 (1923)], and discussions of the same [Abstract 2102 (1923)], and calls attention to the fact that the difference of opinion is connected with a point formerly disputed by Loschmidt and Boltzmann, and which the author has dealt with in his *Physik und Erkentnisstheorie*, p. 111. The second law of thermodynamics, however fully it may hold for processes in which a very large number of molecules are concerned, is still only an approximation, and only such for large molecular numbers. For a few molecules it practically does not hold at all. H. N. A.

446. *The Diminution of Intensity in the Red Region of Solar Radiation, between Europe and the Equator.* **L. Gorczynski.** (Comptes Rendus, 177. pp. 754–757, Oct. 22, 1923.)—Measurements of solar radiation made in Europe, on board ship, and at several stations near the equator, show that in the red region the intensity diminishes on travelling from Europe to the equator; this is partly due to the variation in the zenith distance. Daily observations while travelling show that there is a variation of about 3 % when the sun passes from the zenith to a zenith distance of 50°, but for larger zenith distances the red variation is greater. [**Erratum.** Ibid. 178. p. 264, Jan. 7, 1924.] A. W. L.

447. *Measurements of the Receiving Intensity, of Atmospheric Ionisation, and Other Meteorological Factors Due to the Eclipse of the Sun on April 8, 1921.*

B. Iliin. (Jahrb. d. drahtl. Tele. 22. pp. 128–132, Sept., 1923. From the Russian.)—Gives particulars of measurements as denoted by the title, carried out simultaneously at Moscow, Minsk, and Saratow, with resulting curves. As a result it was found that the receiving intensity at the moment of maximum eclipse passed through a maximum and the atmospheric ionisation through a miminum. This observation agrees with results by other investigators. B. J. L.

ASTRO-PHYSICS.

448. *Radiation and Temperature of External Photospheric Layers.* **R. Lundblad.** (Astrophys. J. 58. pp. 113–137, Sept., 1923.)—In the solar envelope, some investigators assume absorption and radiative equilibrium, others scattering [see Abstract 54 (1920)]. In the earth's atmosphere, radiation round a scattering element is partially polarised and the lack of this in any layer of sunlight shows that here scattering works equally in all directions. The author derives the equation for the energy balance of the beam, and shows how to determine for the radiation in each specified direction, and at each specified layer, the emissivity function $H(m)$; the "collustrivity" function $G(m)$, or average intensity of the radiation converging towards an element of the layer from all directions; and the intensity function $J(m, \xi)$; m_λ being the optical mass with regard to the wave-length λ. He finds that the solar atmosphere cannot be a scattering one solely, either throughout its whole, or in its external layers only, but that the extinction in the sun can be caused either by absorption alone, or by absorption together with scattering within small limits. In any case the scattering is negligible within the red and infra-red parts; most likely it is negligible all through the spectrum. The outermost layers of the sun have an *absolute temperature* of 4500° and the temperature increases with the depth. A table is given showing the correspondence between the optical masses and temperatures with regard to different wave-lengths, and from this, isothermals are traced showing that an appreciable part of the green and blue light come from deep, hot layers, while the radiation of the ultra-violet and part of the infra-red spectrum is due, in the main, to cooler, external layers. The author concludes that the assumption is correct, that the external layers of the photosphere are in radiative equilibrium. A. S. D. M.

449. *Water-Cell Transmissions and Planetary Temperature.* **D. H. Menzel.** (Astrophys. J. 58. pp. 65–74, Sept., 1923.)—The theory of the method is outlined and the influence of the uncertain factors, the area of the planet exposed and the humidity of the atmosphere discussed. Results obtained at present indicate temperature of 50° C. for Venus − 16° C. for Mars, 120° C. for the moon, and − 110° C. for Jupiter and Saturn. These can all be satisfactorily explained by radiative equilibrium except in the case of the two major planets which show unmistakable evidences of internal heat. Mercury, Uranus, and possibly Neptune should be within the scope of the method. The effect of air mass and humidity in the atmosphere can be allowed for as the product of two factors. Further work on infra-red transmission of water-vapour and carbon dioxide is desirable. A. Wh.

LIGHT.

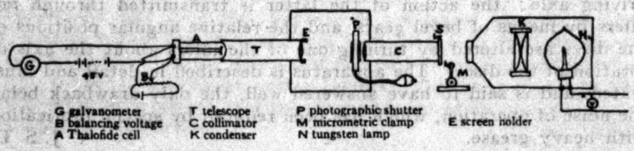
450. *A Photometric Sectored Disc.* **E. Karrer.** (Optical Soc. of America, J. and Rev. Sci. Inst. 7. pp. 893–899, Oct., 1923.)—Describes a photometric sectored disc of which the new features are (*a*) the mode of reading the relative opening; this is done electrically while the disc is in motion by means of a milliammeter at any distance, and (*b*) the method of adjusting the movable disc. Curves are given illustrating the performance of the disc. G. A. S.

451. *A Variable Aperture Rotating Sector-Disc.* **H. E. Ives.** (Optical Soc. of America, J. and Rev. Sci. Inst. 7. pp. 683–687, Sept., 1923.)—In the usual form of sector-disc the opening, once selected, must be adhered to whilst the disc is in rotation. It is, however, desirable that the aperture should be capable of continuous variation whilst the disc is being rotated, and also that the extent of the aperture should be read without stopping the disc. Various attempts have been made to secure these conditions, but, owing to mechanical defects, errors in estimating the aperture are apt to arise. The disc described by the author meets the above reqirements and the aperture can be read from the position of the controlling mechanism without recourse to stroboscopic or other auxiliary means. The mechanical scheme resembles that embodied in Keuffel's apparatus. In this device one disc is rigidly attached to the driving axle, the other floats on the axle and is driven from the first disc, in the opposite direction to it, by an idler with a bevel gear engaging in bevel gears on each disc. In the author's apparatus *both* component discs float upon the driving axle; the action of the latter is transmitted through *two* idlers by means of bevel gears, and the relative angular positions of the discs are altered by turning one of the idlers about the axis of rotation of the discs. The apparatus is described in detail and illustrated, and is said to have answered well, the only drawback being the noise of operation, which has been reduced by special lubrication with heavy grease. J. S. D.

452. *The Opacity of an Ionised Gas.* **J. Q. Stewart.** (Phys. Rev. 22. pp. 324–332, Oct., 1923.)—Years ago J. J. Thomson showed that, owing to scattering of radiation, an atmosphere containing free electrons should possess marked opacity. The present paper now applies to an ionised gas the classical theory due to Drude, Lorentz, etc., of the optical properties of metals supposed to contain free electrons. As a result of collisions with molecules, vibrational energy supplied to the electrons by the electromagnetic field is transformed into energy of thermal agitation. The coefficient of absorption comes out proportional to $\lambda^2 p^2$, where λ and p are the wave-length and pressure. There is also a scattering effect proportional to p and independent of λ, but this is relatively unimportant except at pressures of 10^{-4} atm. or less. The equations developed are tentatively applied to a discussion of: (1) *Opacity of the Vapours of Exploded Wires.*—Anderson, however, reports an opacity 200 times greater than that roughly computed from theory and varying inversely as λ or λ^2, so that further theoretical treatment is required. (2) *Opacity of the Solar Atmosphere.*—Employing Saha's theory to calculate the ionisation, coefficients are computed which indicate that electronic absorption may be an important cause of the opacity of the solar photosphere. It is concluded that light from regions where the pressure is greater than 0·01 atm. is cut off completely, so that all that is seen comes from a spherical shell of rarefied gas. (3) *Opacity of Giant Stars.*—Computations made, assuming the relation between temperature and pressure given by Eddington's theory of stellar constitution, are found in rough agreement with Eddington's values of opacity. H. H. Ho.

453. *Contraction of Volume and Refractive Power of Liquid Mixtures.* **L. Counson.** (Arch. des Sciences, 5. pp. 361–369, Sept.–Oct., 1923.)—Pulfrich established a relation [Abstract 1160 (1910)] according to which the refractive index of a mixture is in excess over what it would have been had the volume and the refractive index been simply additive. Wintgens made measurements on solutions of tartaric acid and of heptamolybdate of ammonium; van Aubel deduced from these measurements that the refractive index was in defect. The author has made measurements on the same solutions, the result of which is to restore Pulfrich's original conclusions. A. D.

454. *Measurement of Photographic Densities.* **C. B. Bazzoni, R. W. Duncan,** and **W. S. Mathews.** (Optical Soc. of America, J. and Rev. Sci. Inst. 7. pp. 1003–1009, Nov., 1923.)—The instrument described makes use of the Thalofide cell as the light sensitive element, connected in series with a potential of 45 volts and a ballistic galvanometer. An adjustable potential is in parallel with the cell to take care by compensation of the slow drift of resistance under applied potential. A spectrometer forms the body of the instrument. The diagram shows the general construction and connections. The method of operation is to place the specimen in front of the slit, spring the shutter for an exposure of generally 1/25 second, and to observe the throw of the galvanometer. In comparing the densities of two films two successive observations are required, and in plotting the variation in intensity across a spectrum line ten to twenty successive observations at intervals of 30–60 seconds are necessary. In this method of measurement the light intensity and condition of illumination must be maintained constant over an extended interval of time. This can be done by using an incandescent lamp operated from a constant source. The Thalofide cell must be depended upon to recover approximately completely during the limited time interval between exposures, which can be done within a few seconds. The photographic shutter must give accurately equal exposures on successive releases. The authors give results of their observations on the broadening of the H_α line in a condensed discharge. [See Abstract 1729 (1921).] T. C. H.



455. *The Grey Wedge and its Use in Sensitometry.* **E. Goldberg.** (Faraday Soc., Trans. 19. pp. 349–354, Nov., 1923.)—Of all methods employed for the production of a great number of measurable light intensities with sufficient accuracy, the Grey wedge has proved most satisfactory. This method was introduced by the author in 1910. The neutral grey wedge has the following special features: (1) The possibility of placing in a very small space an extremely big scale which is practically unlimited. (2) The respective light intensities are placed side by side in a most convenient manner. (3) The intensities increase logarithmically, which is of special importance in photographic technics, as logarithmically-increasing intensities of light correspond with a uniform alteration of the sensation caused by light. (4) The possibility of placing the single intensities of light along a line as well as round a circle, which facilitates the graphical representation of phenomena. (5) These wedges are of very small dimensions, so that the instruments provided with them take up little room and are consequently much cheaper to manufacture than instruments in which measurably graduated intensities of light are obtained in another way. The use of a wedge is especially convenient in all cases where the conditions of light in nature must be studied and relations obtained between the light intensities and the photographic results. A method of determining the degree of halation of photographic plates is described. A specially suitable application of the wedge as exposure device and as photometer is found in the densograph, a new and completed form of which is here described. A. E. G.

456. *Colour of the Sea.* **K. R. Ramanathan.** (Phil. Mag. 46. pp. 543–553, Sept., 1923.)—Raman has recently shown [see Abstract 1578 (1922)] that the deep blue colour characteristic of most ocean waters is due to molecular scattering. In a perfectly absorptionless dust-free ocean of infinite depth the incident light would all be returned unchanged in character and intensity. Water is known to exercise a selective absorption in the red which decreases as the wave-length becomes shorter. Using known values for the absorption of water for different wave-lengths, it is shown that the colour of deep dust-free water on this theory should be the resultant of $1 \cdot 56 \times 10^{-3}$ red, (*i.e.* of wave-length $630 \cdot 2\ \mu\mu$), $2 \cdot 49 \times 10^{-2}$ green ($538 \cdot 1\ \mu\mu$), and $9 \cdot 53 \times 10^{-2}$ violet ($456 \cdot 9\ \mu\mu$), and should approach the spectrum colour $475 \cdot 0\ \mu\mu$, being very near the indigo of the second order in the colours of thin plates. The inclusion of secondary scattering would diminish still further the proportions of red and yellow, for which absorption is strong.

Particles of suspended matter small compared with the wave-length will have little effect unless present in large quantities in which case the absorptive properties of the medium would have less chance to have full play and the blue colour should be less saturated. With larger particles the longer wave-lengths would be returned in greater proportion, and as the amount of matter increased the sea should become greenish blue, green, whitish green, and finally white. Six different samples of sea water, varying in colour from indigo to green, and a sample of dust-free distilled water are examined as regards the intensity of light they scatter transversely when sunlight is incident on them in a dark room. Four of them are also examined as regards the comparative amounts they scatter in different directions, and this is done also for the dust-free water. The results show that suspended matter present in small quantities, although it considerably increases the total scattering, contributes little to the scattering in the direction opposite to that of the incident light. The increase in total scattering reduces the transparency of the medium, but so long as this effect is small compared with the absorption proper, the quality and intensity of the returned light is hardly affected. Thus the colour of the deep sea, where there is little suspended matter, is practically the same as that of dust-free water.

An examination of the quality and intensity of the light scattered by different specimens in reference to the amount of suspended matter shows that the colours cannot be explained by the presence of such matter alone. The results of examining the scattered light for polarisation seem to indicate that in the case of some specimens there is fluorescence, and this is verified by the discovery that colours cut out of the incident light by suitable filters appear in the scattered light. As the incident beam contains no ultra-violet the fluorescence must be caused by an absorption of the blue and the violet. A sea whose water shows fluorescence would thus appear green not only because there is a return of green light but also because there is less blue and violet in the returned light. The water which looks most green shows the most intense fluorescence. The transition from the indigo of the deep sea far from land to blue and green may thus be due either to the increase in the amount of suspended matter present or to the presence of some fluorescent matter, most probably organic. The second cause is apparently the more important. G. A. S.

457. *Glare, Particularly in Relation to Motor-Car Headlights.* **G. Gehlhoff** and **H. Schering.** (Zeits. techn. Physik, 4. 9. pp. 321–333, 1923.)—The authors describe the results of an extended investigation into the effect of various factors on glare, this term being taken to mean interference with visual acuity as determined by the failure to recognise a test pattern on the bright object within a given short interval of time (3 seconds). The experiments were made indoors, with a general illumination of the order of 0·005 metre-candle. Preliminary experiments were carried out to determine the effect due to change of size of the test object, and its distance from the observer. It was found that the determining factor was the angular size and that with increase of size the " blinding " brightness increased to a maximum of the order of 1·5 hefner candles per sq. cm., the size being then about 2½°. The " glaring " illumination at the observer's eye, however, increased rapidly with increase of size of the object.

In a second part of the investigation the definition of glare was taken to be (*a*) the disturbance of vision, loss of direction, and discomfort due to a *sudden* illumination of the retina, and (*b*) the disturbance of vision due to *continued* illumination of the retina. It was found that the minimum brightness giving glare by sudden exposure decreased with increase of angular dimensions of the glaring source, approximately according to the formula, brightness $= a/\sigma + b/\sigma^2$, σ being the angular size of the source. For a constant angular size the glaring brightness was independent of distance. The glaring brightness for continuous exposure was four times that for sudden exposure, the eye being dark-adapted. The influence of the colour of the light was not investigated directly.

J. W. T. W.

458. *A New Method of Investigating Colour-Blindness.* **R. A. Houstoun** and **W. H. Manson.** (Roy. Soc. Edinburgh, Proc. 43. 2. pp. 216–218, 1922–1923.)—The authors have previously described [Abstract 1979 (1922)] the application of their method of testing colour-blindness to congenital cases. Cases of colour-blindness caused by disease are now examined. Instead of daylight a tungsten lamp with a suitable gelatine Wratten screen, to obtain light resembling daylight in colour, was used, and was found to answer well. The present observers were less familiar with physical measurements. But making full allowance for inexperience, results are worse than those recorded in the first investigation. It is, however, difficult to distinguish medical from congenital cases. In the present paper the positions of colours along the three sides of a triangle are given, and diagrams are also presented showing how the vision of subjects differed from that of a normal person, who can usually see 11 steps on the red-blue side, 10 on the red-green, and 9 on the blue-green.

J. S. D.

459. *Stereoscopic Vision.* **J. W. French.** (Optical Soc., Trans. 24. 4. pp. 226–247; Disc., 247–256, 1922–1923.)—The author gives, at the beginning of this paper, a general summary of the historical development of the theory of stereoscopic vision up to the time of Wheatstone and Brewster. He finds that if it be attempted to reproduce the experiments described by Wheatstone the results differ in some important respects from those described. The author emphasises the importance of realising that for the unaided eye, accommodation and convergence are closely, although not rigidly, associated. Normally, a particular condition of accommodation occasions a particular convergence, and to alter the convergence independently of the accommodation involves the exercise of mental effort or the use of artificial aids. From experimental work it appears that stereoscopic vision is possible only within certain limits. For certain pairs of objects on the same or on different horizons there are generally two extreme critical points beyond which stereoscopic vision breaks down. For certain pairs of objects on the same horizon there are two inner critical points. Objects of the same average angular dimensions can frequently be combined stereoscopically although they are of dissimilar form. The image is very indefinite, however. When the angular dimensions are very different combination is generally impossible. When the pairs of objects are dissimilar in size there is only one pair of outer and inner critical points if the objects are on the same horizon, and one outer critical point if they are on different horizons. For pairs of objects any of which can be combined, there are two pairs of such critical points. The results of experimental work on the positions of these critical points and the effect upon them of varying the illumination are given in the paper.

In the *discussion* a number of speakers doubted the effective importance of the relation between convergence and accommodation. **N. M. S. Langlands** described experiments illustrating the effect of convergence on the threshold angle for depth perception. This was, on the average,

3″ for binocular vision and 15″ for monocular vision. Using test plates in a stereoscope the average value was about 40″ [see Abstract 462 (1924)].
J. W. T. W.

460. *Diffuse Reflection of Light from a Matt Surface.* **E. M. Berry.** (Optical Soc. of America, J. and Rev. Sci. Inst. 7. pp. 627–633, Aug., 1923.)—Two methods of explaining the action of a perfect matt surface have been suggested. Bouguer assumed the surface to be made up of countless small mirrors. Another hypothesis assumes that light penetrates a certain distance into the medium and that reflections occur at every point. Grabowski [Abstract 57 (1915)] has contended that the Bouguer hypothesis is untenable. The author develops the theory mathematically and derives equations which are compared diagrammatically with the cosine law. The conclusion is drawn that Bouguer's hypothesis has not been shown to be untenable. Laws obtained for ideal surfaces do not agree very well with observations on matt surfaces. But there are various factors, such as the higher portions of the reflecting surfaces shading some of the lower portions and the influence of diffraction, which have not been taken into consideration. J. S. D.

461. *Refractive Index of Air below Atmospheric Pressure.* **A. Zwetsch.** (Zeits. f. Physik, 19. 5–6. pp. 398–413, 1923.)—The writer opens with a discussion of the literature of the subject and then describes with full details a modification of the Fabry–Perot interferometer which he has designed for the work. It is specially adapted to cover a wide range of pressures and wave-lengths. The results given in the present paper are only for pressures below atmospheric and for $\lambda = 5461$ Å.U. The validity of the formula $n - 1 = Kp(1 + \beta p)$ is verified. Numerically, for air, $K = (0{\cdot}38150 \pm 0{\cdot}00027)10^{-6}$ and $\beta = (0{\cdot}667 \pm 0{\cdot}087)10^{-5}$. Thus at N.T.P. $(n - 1)10^6 = 291{\cdot}41 \pm 0{\cdot}39$. This result agrees closely with that found by Posejpal, but differs from the generally accepted value, *viz.* $(n - 1)10^6 = 293{\cdot}04 \pm 0{\cdot}56$. A. A. D.

462. *Testing Perception of Depth* (*Stereoscopic Visual Acuity*). **H. Kellner.** (Optical Soc. of America, J. and Rev. Sci. Inst. 7. pp. 857–860, Oct., 1923.)—Describes apparatus devised for testing, rapidly and easily, the degree of ability of an observer to perceive differences in depth by stereoscopic vision. The apparatus consists of an ordinary simple lens stereoscope, the object being placed in the focal plane of the lenses. The stereograms represent two rows of parallel lines, similar to two lines of fence posts placed at regular distances apart, there being a small angle between the two lines of posts. The two sets are respectively tinted pink and green and the green lines appear between and *behind* the pink ones at one end of the stereogram, and between and *in front of* the pink lines at the other end of the stereogram. The observer sees three lines at a time, one green line between two pink ones. The step provided between adjacent green lines is 5 seconds of parallactic angle. The number of steps made before an observer recognises the centre line as displaced from the plane defined by its two neighbours is noted for displacement on each side of zero. J. W. T. W.

463. *A Method of Studying Surfaces and Optical Systems.* **V. Ronchi.** (Accad. Lincei, Atti, 32. ii. pp. 162–164, Sept., 1923. N. Cimento, 26.

pp. 69–71, July, Aug.–Sept., 1923.)—An experimental arrangement is described which it is claimed can be modified so that the aberration and irregularity of lenses, etc., can be examined and measured not only on the axis but in any region of the field. A. E. G.

464. *Form of the Wave Surface after Refraction.* **A. Whitwell.** (Optical Soc., Trans. 24. 4. pp. 209–221 ; Disc., 221–225, 1922–1923.)—The author applies the graphical method to the determination of the form of the wave surface produced when a plane or spherical wave is refracted by various forms of refracting surface or by a lens. The form of the wave surface when coma and astigmatism are present is found in certain special cases. The peculiar characteristics of the wave surface in the region of the focus are discussed, and the position of best focus is defined, as well as the term "depth of focus." In the *discussion*, **T. Smith** pointed out that the graphical method gives useful results only when the aberrations involved are large, while **T. Y. Baker** showed a method of inferring the wave surface from the form of the caustic. J. W. T. W.

465. *Formation of the Image of a Diffraction Grating by a Microscope Objective.* **A. Driesen.** (Zeits. f. Physik, 18. 3–4. pp. 131–168, 1923.)—Describes the results of an experimental investigation of the effect of various aberrations on the form of the image given by a microscope objective when viewing a diffraction grating illuminated by very accurately parallel light. A theoretical treatment of the subject is given and the results obtained experimentally are illustrated by actual photographs. J. W. T. W.

466. *The Primary and Secondary Image Curves Formed by a Thin Achromatic Object Glass with the Object Plane at Infinity.* **E. W. Taylor.** (Optical Soc., Trans. 24. 5. pp. 321–325 ; Disc., 325, 1922–1923.)—The shapes of the primary and secondary image curves formed by a thin simple lens of an object plane at infinity are well known, and can be readily determined. The object of this paper is to show that the image curves in the case of a double object glass of ordinary thickness, and with the inner curves approximately in contact, correspond very closely to those of a simple lens of the same power, and are only very slightly affected by the use of different glasses. AUTHOR.

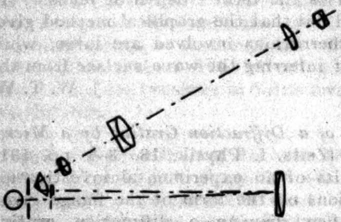
467. *Surveying and Navigational Instruments from the Historica Standpoint.* **L. C. Martin.** (Optical Soc., Trans. 24. 5. pp. 289–303, 1922–1923.)

468. *Early Telescopes in the Science Museum, from an Historical Standpoint.* **D. Baxandall.** (Optical Soc., Trans. 24. 5. pp. 304–320, 1923.)

469. *Focal Line Method of Determining the Elastic Constants of Glass.* **G. F. C. Searle.** (Cambridge Phil. Soc., Proc. 21. pp. 772–780, Nov., 1923.)—A thin plate of glass is first bent and then twisted by equal and opposite couples. Measurement of the principal radii of curvature of the surface enables the elastic constants to be determined. These

measurements are made optically. Expressions are first deduced for the positions of the focal lines and then the experimental arrangements are described. Finally a set of figures from an actual experiment is given.
A. A. D.

470. *Prism Testing.* **G. W. Moffitt.** (Optical Soc. of America, J. and Rev. Sci. Inst. 7. pp. 831–852, Oct., 1923.)—Describes a simple instrument designed primarily for the rapid routine testing of Porro prisms (45° – 45° – 90°) by a modification of the auto-collimating method of Chalmers and Ryland (Optical Soc., Trans. 6. p. 34, 1904–1905). The optical system is shown in the diagram. A lamp with frosted bulb illuminates a pinhole and also the rulings of a reticule placed just above the pinhole. The light from the pinhole passes horizontally to a good objective, quite free from zonal aberrations and from coma, and thence to the prism under test. The reflected ray forms an image of the pinhole on the reticule. The remainder of the optical system is a compound microscope of magnification about 60 diams., together with a change-direction prism which enables the position of the eye to be arranged conveniently with respect to the prism table. The methods of dealing with different forms of prisms are described in the paper. The accuracy attainable in the case of an equilateral prism was found to be equal to that given by a high-grade spectrometer, while the speed of testing for Porro prisms was found to be over 200 per hour (where no record of performance is kept). Both the definition and the deviation errors of the prism are tested, as well as its pyramidal error.
J. W. T. W.



471. *Longitudinal Aberration in Aspherical Optical Systems.* **I. Roman.** (Optical Soc. of America, J. and Rev. Sci. Inst. 7. pp. 861–872, Oct., 1923.)—A mathematical study of lenses having non-spherical surfaces of revolution generated by the curve $x = x_0 + \gamma_1 y^2 + \gamma_2 y^4$. These surfaces may be characterised by the coefficient of form $B = 1 - \gamma_2/\gamma_1^3$, which is zero in the case of a sphere. The results obtained are confined to the longitudinal aberration, since this is the only second order defect which is influenced by a departure from sphericity of the kind considered. Several formulæ are derived for the aberration, and each of these involves B, so that by properly selecting B the final aberration may be reduced or even eliminated. The amount of retouching necessary at any part of the lens is of the fourth order in the optical height of the ray passing through that part and is given by $\xi = Bh^4/8a^3$, where a is the radius of curvature of the spherical surface. The use of the method is exemplified in the case of the Dallmeyer "Rapid Landscape" lens, a cemented triplet of focal length 102·88 mm. At aperture $f/11$ the initial value of h is 4·52 and the aberration is – 3 units. The maximum amount of retouching to remove second order longitudinal aberration completely is 0·0026 mm. whether the initial or final surface is retouched. The "sign" of the retouching, *i.e.* most or least at centre, is, however, different according to the surface chosen.

By the use of this method a lens system may be designed with only secondary regard to longitudinal aberration, this being removed by retouching in a definitely known manner. In camera lenses, where large apertures are needed, the higher order terms may make this method of questionable value. For telescope systems in which second order terms are sufficient, however, the method is particularly suitable. J. W. T. W.

472. *Interference Figures Produced by Transparent Inactive Crystalline Plates in Convergent Polarised Light.* **F. E. Wright.** (Optical Soc. of America, J. and Rev. Sci. Inst. 7. pp. 779–817, Oct., 1923.)—These phenomena are best understood by the use of a single surface of reference from which is derived, step by step, the several relations presented by crystals in polarised light. The author derives the standard equations required by the petrologist by means of direct methods based on the conception of a sphero-conic, *i.e.* the curve of intersection of an ellipsoid with a concentric sphere of given radius ρ. Radii vectores, drawn to the points of this curve, form a central cone, the intersection of which with the sphere of unit radius marks the position in space of all radii vectores of the ellipsoid of length ρ. The behaviour of a wave of light on passage through a crystal in a given direction can be accurately predicted by considering the diametral plane of the index ellipsoid, normal to this direction. Along the principal axes of the ellipse made by the intersection of this plane with the index ellipsoid, the vibrations take place and the refractive indices of the two waves formed are directly proportional to the length of these axes. The sphero-conic, ρ, marks the positions in space of all vibration directions along the radii vectores of length ρ. For this reason the name *equi-vibration curve* is suggested to designate each one of the series of sphero-conics formed in this manner. The direction of wave normal propagation, corresponding to a given vibration direction and represented by a point on a given sphero-conic, is found by passing through the given point a plane tangent to the central cone which passes through the given sphero-conic. The normal to this diametral plane is then the desired direction, while the plane itself is the wave-front. This operation leads at once to the equation of the index surface whose radii vectores are proportional to the refractive indices (reciprocals of the velocities) of the wave-normals. For a given refractive index, ρ, the equation of the index surface can be interpreted as that of a central cone, the intersections of which with a sphere of unit radius form a sphero-conic, which represents the positions in space of all wave normals of refractive index ρ. These sphero-conics may therefore be appropriately called *equi-refringence curves*. From the properties of these equi-refringence curves, the phenomena observed both in parallel polarised light and in convergent polarised light on inactive transparent crystal planes can be deduced. From them the fundamental rules and equations of crystal optics needed by the petrologist are derived directly in the body of this paper. It is considered that by thus attacking the problems from a suitable viewpoint, a degree of simplicity and directness has been attained which is not possible by other methods. J. W. T. W.

473. *A Species of the Jamin Interference Arrangement.* **E. Bratke** and **E. Waetzmann.** (Ann. d. Physik, 72. 7. pp. 501–515, Nov., 1923.)—This paper contains the exposition of a rigid theory concerning an interference phenomenon closely related to that of Jamin and previously treated by Mascart, Lummer, and Hurion, in which rays of light incident at less than 45° on a plane parallel plate are reflected upon a lens and thence reach a mirror from which they again return *via* the lens to the plate, and, finally, to the eye. The calculation presented is a special case of a generalisation for optical systems previously recorded [see Abstract 395 (1913)]. Former investigations are critically discussed. The conclusion is drawn that all deviations in the shapes of the interference curves from perpendicular straight lines are due exclusively to error in the point construction of optical systems, and based on this view an accurate method is now derived. The paper is mathematical throughout. H. H. Ho.

474. *Achromatic and Superchromatic Fringes.* **C. Barus.** (Nat. Acad. Sci., Proc. 9. pp. 373–376, Nov., 1923.)—This is an advance note from a report to the Carnegie Institute, Washington. An account is given of experiments in which interferometers with plate-glass compensators and an Iceland-spar compensator were used. The fringes obtained with a calcite block 3 cm. thick and with a nicol 7 cm. long are described. J. J. S.

475. *Diffraction Image of Two Close Luminous Planes.* **O. E. Mourashkinsky.** (Phil. Mag. 46. pp. 802–815, Nov., 1923.)—The problem of the resolution of two luminous planes is treated from the standpoint of its identity with that of the diffractional conditions of the visibility of a band of finite width on a bright background. The resolving power of an object glass for two luminous planes depends on the distribution of illumination in the diffraction image of these planes, so the author first determines the illumination at any point in the diffraction image of two planes due to a circular aperture. Two luminous sources with straight edges (lines, bands, infinite planes with straight edges) give a more simple diffraction pattern in a focal plane of an object glass than 2 luminous points or discs, since all the isophotes of the first are always straight lines parallel to the edge. It suffices, therefore, to know the distribution of illumination along one line perpendicular to the edge, and results are given for 2 luminous planes of equal brightness with a dark band of width D between them for different values of D. Five characteristic points of these curves are noted: (1) The point of minimum illumination at the axis of a central band; (2) two points corresponding to the geometrical images of the edges; (3) two points at which the illumination differs from the general illumination by but a small fraction. The illumination at the axis for small values of D is found to differ little from that at the edges, but for greater values it decreases very rapidly. A diffraction image of 2 luminous planes with a dark band, or, one of some brightness between them, is found to serve as a convenient object for determination of the contrast sensibility of the eye. H. H. Ho.

476. *Universal Interferometer.* **A. E. H. Tutton.** (Roy. Soc., Proc. 104. pp. 47–62, Aug. 1, 1923.)—The essential novelty of the interferential comparator for standards of length, designed by the author [Abstract 51 (1910)], was that each of the two travelling microscopes was given so fine and steady a movement that the plane surface of a black glass disc carried by the microscope could form one of the two reflecting surfaces producing the interference bands. The success of the instrument, owing to the steadiness and perfect control of the movement of the interference bands obtained, suggested the suitability of employing such a microscope, together with the optical train and a suitable length of V-and-plane guiding bed, as an interferometer of the most perfect character and general application for the measurements of small amounts of motion, slight deformations, short distances, or minute objects of any nature whatsoever. The paper describes in detail the design and method of adjustment of the interferometer. The interval between two interference bands (corresponding to a movement of the mirror of $0 \cdot 5\lambda$) is readily divisible into $\frac{1}{100}$ parts by a micrometer; thus the measuring unit of the instrument is about one eight-millionth of one inch. T. H.

477. *The Free Electron Characteristics of Sodium-Potassium Alloys.* **C. V. Kent.** (Phys. Rev. 22. pp. 479–485, Nov., 1923.)—The paper is a continuation of a previous communication [Abstract 1417 (1920)] in which the author gives results for liquid alloys of lead with Bi, Sn, Cd, and Hg. Recently Morgan [Abstract 146 (1923)] published determinations of the optical constants of liquid Na–K alloys at temperatures below 100° C. The impact frequency and density of free electrons calculated from the optical data of Morgan are given. The chief source of uncertainty is the determination of the effect of the bound electrons on the optical constants. The number of free electrons per atom is found to be about $1 \cdot 5$ for all the alloys, but with indication of a minimum of about $1 \cdot 2$ for the $\frac{1}{3}$ sodium alloy. The frequency of impact of a free electron with molecules comes out from 1 to 3×10^{14}, less than the frequencies found for the metals previous investigated. The impact frequency increases linearly with increase in per cent. of either constituent to a maximum for the compound NaK supposed to exist in these liquid alloys.

The resistivities calculated from the optical constants agree with experimental data for the pure liquid metals and for two alloys within the limits of error. The variation of resistivity with composition is compared with values for Na–K alloys at 200° C. These results tend to show that the simple Drudean optical theory holds for liquid alloys which form compounds as well as for those which do not. W. V. M.

478. *Improved Temperature Control for Pulfrich Refractometer.* **T. M. Lowry** and **R. G. Parker.** (Journ. Sci. Instruments, 1. pp. 16–21, Oct., 1923.)—A description of improvements as now applied by Hilger; wider tubes and an additional water jacket. Comparative measurements. A. D.

479. *Relative Velocity of Blue and Yellow Light.* **H. Shapley.** (Nat. Acad. Sci., Proc. 9. pp. 386–390, Nov., 1923.)—Astronomical observations were made on the globular cluster Messier 5, the distance of which has been determined by various methods to be $2 \cdot 3 \times 10^{17}$ miles. There are in this group nearly a hundred cluster-type variables with periods ranging from 6 to 20 hours. Photographs of Messier 5 were taken in 1917, using the 60-inch reflector of the Mount Wilson Observatory. Exposures of 20 to 30 minutes were made to record the yellow light with isochromatic plate and yellow filter, and these exposures were interrupted in the middle to expose an ordinary plate for two or three minutes to the blue light. A table of the results of measurements is given from which it is derived that the difference in time required for the passage of blue and yellow light over a distance of 40,000 light-years is: Blue − Yellow = − 10 ± 60 seconds. The maximum effective wave-lengths observed were 4500 Å. and 5500 Å. respectively, and it is considered that the velocities do not differ by more than one part in twenty thousand million. A graphical check on the result was also made. G. E. A.

480. *Direct Reading Photoelectric Transmissometry.* **K. S. Gibson.** (Optical Soc. of America, J. and Rev. Sci. Inst. 7. pp. 693–704, Sept., 1923.) —In continuation of earlier work on null photoelectric measurements [Abstract 98 (1920)], it is shown that many photoelectric cells cannot be applied to this form of measurement. A new system, nearly as accurate as the old, and rather more convenient is described. This consists of a source of light focused on the slit of the spectroscope, a Brodhun variable sector, and a photoelectric potassium cell and quadrant electrometer. The specimen to be measured is inserted before the slit of the spectroscope and the sector set at 100·0. The deflection is noted and the specimen removed. The deflection is then reduced to the same value by adjustment of the sector, which then reads the transmission directly. This method is also applied using a thermopile and galvanometer, to the red and infra-red spectrum range. A. Wh.

481. *Rotatory Dispersion in Absorbing Media.* **E. O. Hulburt.** (Phys. Rev. 22. pp. 180–187, Aug., 1923.)—Electron theory of magnetic and natural rotatory dispersion extended to take account of absorption. Simplified approximative formulæ obtained, which give the rotation for wave-lengths sufficiently removed from the critical wave-length, provided that the refractive index and extinction-coefficient conform to the Lorentz dispersion equations with one resonance frequency; agreement with experimental results for CS_2 and α-monobromnaphthalene [see Abstract 121 (1922)]. A. D.

482. *Atmospheric Optical Polarisation.* **S. Aurino.** (Accad. Lincei, Atti, 32. ii. pp. 71–76, Aug., 1923.)—Observations at Naples on the positions with respect to the sun and the anti-sun of Babinet's and Arago's neutral points. Variations in these with the degree of transparency of the atmosphere. A. D.

483. *Dispersion of Magnetic Double Refraction.* **G. Szivessy.** (Zeits. f. Physik, 18. 2. pp. 97–104, 1923.)—The relative retardation ψ of the two polarised rays produced by a medium of thickness l when in a field H is $\psi = ClH^2$. Havelock has shown that the constant C is given by $h\frac{(n^2-1)^2}{n\lambda}$, where n is the refractive index and λ the wave-length of the rays. The question of the validity of Havelock's law having been raised, measurements were made for a series of organic liquids, the retardation by means of a Brace half-shadow instrument, and the refractive index by a Pulfrich refractometer. The applied magnetic field was 10,100 gauss as determined by a bismuth spiral. The experiments show that at constant temperature the factor h is independent of the wave-length employed, and that for the liquids tested the dispersion of magnetic double refraction follows the Havelock law. [See also Abstract 1352 (1923).] G. E. A.

484. *Polarisation Effects in Films of Fused Salts.* **D. B. Deodhar** and **G. B. Deodhar.** (Phys. Rev. 22. pp. 405–407, Oct., 1923.)—Experiments made by Talbot and the late Lord Rayleigh have been repeated. Fused films of nitre observed under a microscope and between crossed nicols showed irregularly distributed patches varying in colour and brightness. The effect has now been found not only with potassium nitrate and chlorate but with silver nitrate and benzoic acid. The intensity diminishes with time, but the variations can still be observed after six months. A film formed by evaporating a binary solution of a mixture of any pair of the following: Alum, boric acid, borax, and citric acid, also showed the effect, although films with only one constituent were inactive. The effect appears to be the result of mechanical strains developed on cooling the film. J. J. S.

485. *Experimental Test of Oseen's Theory of the Rotatory Power of Optically Active Liquids.* **A. Gumprich.** (Phys. Zeits. 24. pp. 434–437, Oct. 15, 1923.)—Oseen [Abstract 188 (1916)] has deduced that in optically active liquids $[\alpha] : (n^2 + 2) = \text{const.}$, provided that the active molecules do not unite with one another or with the solvent. Since the rotatory power of camphor can be extrapolated to the same limiting value from readings in different solvents, it is assumed to be free from the tendency to form complexes. Nevertheless, tests of Oseen's law show no proportionality between the specific rotatory power of the camphor and the refractive index of the solution [compare Wetterfors, Abstract 1986 (1922)]. T. M. L.

486. *Photoluminescence of Flames.* **E. L. Nichols** and **H. L. Howes.** (Phys. Rev. 22. pp. 425–431, Nov., 1923.)—*Effect of light on the intensity of the flame spectra of Li, Na, Ca, and Sr.*—The salted flame of an air-hydrogen blast lamp was illuminated with the full light from a tungsten lamp, a carbon arc, a mercury arc and an iron spark, and the intensity of the bands or lines emitted, as determined by a photometric balance method in connection with a spectrometer, was found to be increased in all cases. The iron spark was most effective, the increases being over 10 per cent. for Ca and Sr. Not only the ultra-violet beyond $0 \cdot 3\,\mu$ is effective but also light above $0 \cdot 43\,\mu$. Red or yellow light of the wave-length absorbed by the flame, however, had a quenching effect, reducing the intensity 2 or 3 per cent. and decreasing the effect of the spark alone by half. No change in the distribution of intensity in the spectra seems to be produced, all bands being equally affected. That true luminescence is produced is shown by the fact that the intensity is the same in all directions. AUTHORS.

487. *The Special Ultra-Red Oscillations of Salts Containing Sulphur.* **V. J. Sihvonen.** (Zeits. f. Physik, 20. 5. pp. 272–279, 1923.)—Schaefer and Schubert have carried out a comprehensive series of measurements with the ultra-red reflections of inorganic substances from which the nature of the cation appeared to be of little influence, while, on the other hand, relationships were discovered for sulphates and carbonates, selenates and chromates, chlorates, bromates and iodates [see Abstract 862 (1921)]. The present paper deals with the reflection spectra of sulphur-containing salts, and in particular compares the special short-wave ultra-red frequencies of such anions as contain a sulphuryl, or at least a thionyl, group. Experimental details are given very fully, the apparatus being similar to that of Schaefer and Thomas [see Abstract 1576 (1923)]. The crystals examined were, $Na_2SO_3 . 7H_2O$, $BaSO_3$, $C_2H_5SO_3Na . H_2O$, $C_2H_5SO_3K . H_2O$, $Na_2S_2O_3 . 5H_2O$, $K_2S_2O_3 . H_2O$, $BaS_2O_3 . H_2O$, $Na_2S_2O_3 . 2H_2O$, $K_2S_2O_6$, $BaS_2O_6 . 2H_2O$, $K_2S_3O_6$, $K_2S_4O_6$, and preparation details of these are included. Sulphates and sulphites are found to possess a characteristic reflection maximum in the wave range from 8 to 11 μ, which according to the crystal system of the salt may indicate complexity, since all the other salts possess in the same region two widely separated special oscillations. This difference is ascribed to the inner structures of the sulphate and sulphate ions being more symmetrical with respect to the sulphur atom than the other anions. A discussion is given of the data from the standpoint of the valency theory. The sulphone group is opined to possess the oscillations of the groups SO_2 and SO_3, and the observed long-wave maxima are ascribed to the existence of these groups. H. H. Ho.

488. *Monochromator for the Ultra-Violet, Visible, and Near Infra-Red.* **R. T. Beatty.** (Journ. Sci. Instruments, 1. pp. 33–42, Nov., 1923.)—The author describes a monochromator designed so as to be readily adaptable to various uses in a research laboratory. Its component parts are (i) two optical benches arranged with their axes mutually at right angles, (ii) a slit and collimating lens mounted separately in holders supported on one bench, (iii) a slit and telescope lens on the other bench, (iv) a 60° prism and a plane mirror mounted at the junction of the bench axes, so as to give a constant deviation system. The lens used is 3½ ins. across a slant face. For visible light the lenses and prism are of glass. For the extra-visible parts of the spectrum a quartz prism is used with collimating and telescope combinations of quartz-fluorite. The collecting lens is replaced by a concave mirror covered with nickel or silicon. The glass and quartz-fluorite achromats are of equal focal lengths, so that no focusing adjustments are required when changing the optical system from glass to quartz. The component parts are fully described and illustrated in the paper. J. W. T. W.

489. *Radiation from the Incandescent Gas Mantle.* **E. Podszus.** (Zeits. f. Physik, 18. 3–4. pp. 212–216, 1923.)—The author discusses the effect of admixture of cerium oxide with the thorium oxide in a gas mantle, in producing increased luminosity when the mantle is heated. Experiments are made with a tungsten wire electrically heated to different temperatures and coated with thin layers of these oxides. A. B. W.

490. *Proof of the Law of Photochemical Equivalence and the Dry Plate.* **J. Eggert** and **W. Noddack.** (Zeits. f. Physik, 20. 5. pp. 299–314, 1923.)—The absorption relations of a dissolved and dispersed silver bromide, of clear and disperse gelatines, as well as two types of dry plates, are according to three different methods for six regions of the spectrum investigated. The true absorption of silver bromide, taking into consideration the properties of silver bromide and gelatine, is calculated from these measurements. The amount of metallic silver in the lighted silver bromide gelatine layers is investigated by Volhard's method. The loss of silver by fixing a plate under different conditions is also determined. [See also Abstract 1842 (1923).] A. E. G.

491. *Photochemistry of the Photographic Dry Plate. Part II.* **F. Weigert.** (Zeits. f. Physik, 18. 3-4. pp. 232-237, 1923.)—The author considers that the new experiments of Eggert and Noddack [Abstract 1842 (1923)] are more in accord with his conclusions [Abstract 1738 (1922)] than with their own. They suggested that, in the short-wave spectrum, the greater portion of the light would be absorbed by the gelatin without producing any photochemical effect, having, in their experiments with gelatin plates of quite unusual thickness (0·88 to 1·5 mm.), now found that the absorption increased from the red towards the violet. That, the author objects, would simply be due to the brownish-red colour of thick gelatin layers. According to Freundlich, the extinction spectrum of disperse systems varies qualitatively with the grain size and the distribution and density of packing of the grains ; silver bromide in an emulsion absorbs also in the green and red, which fused silver bromide does not do. The author admits an error in his previous paper, but maintains that the validity of the photochemical-equivalent law has not been established for a photographic bromide plate. H. B.

492. *Proof of the Photochemical Equivalence Law in Silver Halide Emulsions.* **J. Eggert.** (Phys. Zeits. 24. pp. 488-489 ; Disc., 490, Nov. 1-15, 1923.)—The usual methods are here employed, but special attention is paid to the following means of obtaining more exact results. Great care is taken to ensure that the source of light shall be rigidly monochromatic. An improvement in the absorption measurements of the silver bromide layers is adopted, and the chemical analysis of the quantity of silver present is more exact. It is shown that for long periods of lighting the number of photolysed silver atoms is no longer proportional to the time, the ratio of the number of Ag-atoms to the number of quanta decreases with high exposures. [See also Abstract 1842 (1923).] A. E. G.

493. *Theory of Photography.* **W. D. Bancroft.** (Faraday Soc., Trans. 19. pp. 243-255, Nov., 1923.)—The outlines of a theory of development are dealt with under the following heads : The emulsion, plate sensitiveness, grain sensitiveness, latent image, the developer. [See also Abstracts 1585 and 1586 (1922).] A. E. G.

494. *The Mechanism of the Latent Image Formation* **F. C. Toy.** (Faraday Soc., Trans. 19. pp. 290-295, Nov., 1923.)—Svedberg was the first to discover [see Abstract 1585 (1922)] that there is something more fundamental than the grains themselves, this being the "centres," *i.e.* the points in the grains from which development starts. This paper mainly deals with a discussion of the nature of these centres, since it is on them that the sensitometric characteristic of any emulsion chiefly depend. There is a great controversy as to how these centres are formed. The different views are summarised as follows : (1) They are formed in homogeneous grains entirely by the light which is incident at points on the plate in finite discrete quantities, (2) they are pre-existent in the grains before exposure as a chemically different substance, the function of the light being to change their condition in such a way that they become capable of acting as reaction centres. The light is considered as incident equally on all grains. (3) By a combination of (1) and (2) ; heterogeneous radiation incident on grains containing specially light sensitive points.

Each of these is considered separately. It is concluded that for progress in the solution of the latent image problem these facts must be borne in mind: (1) The light dart theory cannot explain the mechanism of exposure. (2) Light is incident equally on all the grains. (3) The centres are specially light-sensitive points where traces of foreign matter exist. (4) The relation between the number of centres produced and the quality of the light is of the order to be expected when the light absorption by the grains is considered. A. E. G.

495. *Exposure Theories.* **S. E. Sheppard, A. P. H. Trivelli,** and **E. P. Wightman.** (Eastman Kodak Co. Research Lab. Comm. No. 179. Faraday Soc., Trans. 19. pp. 296–308, Nov., 1923.)—There are two principal periods of development of such theories. In the first period the salient features were the assumptions (1) of homogeneity and continuity of the sensitive emulsion, (2) of a like condition of the incident radiation, and (3) of the same for the developed image. The essential characteristics of the second period are (1) the full recognition of the microscopically and submicroscopically disperse character of the emulsion and (2) the assumptions (*a*) that the light may be heterogeneous, *i.e.* radiated and absorbed in discrete quanta, (*b*) that the grains of the emulsion may be inherently heterogeneous as to their sensitivity, and (*c*) that (*a*) and (*b*) may both have to be taken into account. In this paper certain relations between the theories of the two periods are considered and the following points are specially dealt with. Absorption of light and photocatalysis. Grains and differential grain sensitivity. A. E. G.

496. *Optical Properties of the Photographic Emulsion.* **F. E. Ross.** (Faraday Soc., Trans. 19. pp. 379–382, Nov., 1923.)—The distribution of light in the emulsion is first considered. Bouguer's law holds with a fair degree of accuracy in specifying the light intensity within the film, in the region beyond and contiguous to the true edge of a sharp image. This has been proved by the fact that images grow in diameter at a uniform rate, from which Bouguer's law of light distribution has been shown to follow as a mathematical consequence. A recent investigation of the subject by the writer using the most refined data, has led to a more precise law of intensity, given by the equation $\log (I/I_0) = - K [\sqrt{x+h} - \sqrt{h}]$ where x is the distance from the true edge of an image and h is a parameter. The resolving power and sharpness is next dealt with. It is found that the resolving power depends on the wave-length of light used, it being greatest for violet light, diminishes rapidly towards the green, then increases again as the red end of the spectrum is approached. It was found that the same law of variation with wave-length holds for sharpness. Resolving power in addition is dependent on the contrast between the detail and its background. A. E. G.

497. *Photoluminescence of Dyestuffs in Viscid Solutions.* **A. Carrelli** and **P. Pringsheim.** (Zeits. f. Physik, 18. 6. pp. 317–324, 1923.)—The duration and the polarisation and, in some cases, the amount of luminescence vary with the viscidity, but no general relation can be established. Where with increasing viscosity the fluorescence passes directly into a similar phosphorescence, both the fluorescence and the phosphorescence are strongly polarised. The fluorescence and phosphorescence of uranium and didymium glass and of Lenard's phosphor are not polarised. A. D.

498. *The Luminescence of Titanium Oxide.* **E. L. Nichols.** (Phys. Rev. 22. pp. 420–424, Nov., 1923.)—(1) *Kathode rays* excite only very faintly some orange-red bands unless the oxide has been recently fused, when the light excited has a fine blue colour and includes three bands with heads at 0·625, 0·550 and 0·425 μ. The fatigue is rapid. (2) *Ultra-violet light* from an iron spark was ineffective. (3) *Under flame excitation,* a sample of the oxide placed on a copper block showed luminescence which was greyish blue at 425°, a strong red to 677° when it suddenly changed to a yellow. (4) *Heated to incandescence* by an oxy-hydrogen flame, two distinct phases were observed. Phase R (hydrogen in excess) showed a reddish luminescence reaching a maximum intensity at about 985° C. of about eleven times black body radiation. Phase O (oxygen in excess) showed a modified blue glow greatly in excess of black body radiation throughout all the visible and for all temperatures below 1200° C. AUTHOR.

499. *Radio-Chemistry and Fluorescence.* **J. Perrin.** (Comptes Rendus, 177, pp. 612–618, Oct. 8, and pp. 665–666, Oct. 15, 1923.)—For a number of fluorescent solutions, intensely illuminated at constant temperature, it was found that the fluorescent substance gradually disappears and that, for any given illumination, the velocity of this disappearance is at a maximum when the solution is very dilute and highly fluorescent [Abstract 1214 (1919)]. The conclusion that fluorescence constitutes an accompaniment of a chemical transformation agrees with the general radio-chemical theory advanced by the author and also by Lewis, but MacLennan and also Levaillant (Comptes Rendus, 177. pp. 398–401, 1923) find that an essential part in such transformation is played by the solvent or by the air. In the light of this observation, the author modifies his views and gives the results of further experiments in illustration of his theory. T. H. P.

500. *Luminescence Produced by X-Rays.* **A. J. de Beaujeu.** (J. de Physique et le Radium, 4. pp. 257–267, Aug., 1923.)—An outline is given of a large number of observations of the phosphorescence excited by X-rays in minerals and organic compounds; the author draws the following conclusions: (1) A large number of solid organic compounds exhibit fluorescent effects on excitation by X-rays. (2) Substances of the aromatic series show the greatest fluorescence, and it appears that the benzene ring is the principal "fluorophore."

The degree of purity is a very important factor in luminescence, the greater the purity of the substance the more brilliant is the light emitted. Strongly coloured substances do not appear to be excited to luminescence by X-rays. A. B. W.

501. *A Spectrometer Table.* **B. J. Spence.** (Optical Soc. of America, J. and Rev. Sci. Inst. 7. pp. 853–856, Oct., 1923.)—A table consisting of a cone-borne disc actuated by a thin steel strap stretched by a counterpoise and displaced by a screw with a divided circle rotated by a long rod. The observer's body is then not in proximity to the radiometer, thermopile, or bolometer. Readings are effected by means of a telescope. A. D.

502. *A type of Arc in Vacuo Suitable for the Production of the Spectra of Metals of which only Very Small Quantities are Available.* **B. Perrette.**

(Comptes Rendus, 177. pp. 876–879, Nov. 5, 1923.)—The usual carbon arc *in vacuo* does not give as sharp spectra lines as those obtained from luminous gases under small pressure. The method employed by the author consists in producing *in vacuo*, an arc between a kathode raised to incandescence by an auxiliary current and an anode carrying a small quantity of the metal to be studied. The kathode consists of a pure tungsten wire and the anode is a tungsten plate having a cavity containing the metal. The arrangement has the advantage of being regular in action, rarely requiring replacement of filaments and of being easily worked at a good vacuum. Examples of the fineness of spectra obtained from lead are given, and it is claimed that very little material is used up in the experiments. W. V. M.

503. *The Absorption Spectra of the Vapours and Solutions of Various Ketones and Aldehydes.* **J. E. Purvis.** (Chem. Soc., J. 123. pp. 2515–2521, Oct., 1923.)—The work is a continuation of the previous results by Purvis and McCleland (T. 1912. 101. 1810). The author has investigated various substances containing an aldehydic or a ketone group and finds that (1) camphorquinone vapour exhibits a few bands in the visible region of the spectrum while camphor, fenchone, and carvone have each a single band in the ultra-violet, and camphoric anhydride has none. (2) Carvone-oxime, camphoric anhydride, and camphorimide have no solution bands in the visible or the ultra-violet, and that (3) dextrose, lævulose, and lactose have specific solution bands in the ultra-violet characteristic of aldehydes and ketones, while sucrose has none. Formaldehyde and glyoxal exhibit numerous bands which disappear in the more complex acetaldehydes and acetones.

A suggestion with respect to the causes of the similarities and differences exhibited is made, in terms of vibrating centres of the various molecules. Reproductions of photographs of the absorption bands of the vapour of camphorquinone at various temperatures and pressures are given.

W. V. M.

504. *Variation of Intensity of Spectral Lines with Gas-Pressure.* **L. Strum.** (Zeits. f. Physik, 18. 6. pp. 372–378, 1923.)—The author deduces the following expression for the light-energy E, in a given spectrum line $E = \delta \frac{p}{\lambda} \cdot e^{-\gamma n^4 p^{2/3}}$, where δ and γ are constants, p is the gas pressure, n the quantum number, and λ the wave-length. This relation gives the variation of intensity of spectrum lines with gas-pressure and with the position of the lines in the series. The theory is confirmed by experimental results. A. B. W.

505. *Spark Spectra in Liquid Non-Metals.* **M. Curie.** (Comptes Rendus, 177. pp. 1021–1023, Nov. 19, 1923.)—The author has previously shown that the chief reason for the production of continuous spectra in highly condensed media is the non-uniformity of the field of force acting upon an electron, due to the intermolecular forces. This cause should exist, whatever atoms are present. The present work is an endeavour to see if the continuous spectrum seen when a spark is passed under a liquid is always connected with the presence of hydrogen; for it is to this gas that the wide continuous band is supposed to be due when the spark passes between points under water. Platinum points were used with liquid bromine, oxygen and nitrogen, and molten sulphur and phosphorus. A highly condensed spark was obtained from an induction coil. With all these liquids, a wide continuous band was obtained; the long wave-length limit was about 725 $\mu\mu$; the short wave-length limit depended upon the absorption of the liquid. In none of the liquids examined was there any persistence of the emitted light. A. C. M.

506. *Variations of Structure and Intensity in Band Spectra due to Molecular Interaction.* **M. Toussaint.** (Zeits. f. Physik, 19. 4. pp. 271–300, 1923.)—Changes in band spectra analogous to those caused by variations of temperature or pressure are to be expected on the introduction of a foreign gas, other conditions such as pressure, current, and temperature being kept constant. The spectra of H, O, N, C + O, C + H, C + N were observed in the positive column by passing pure H, O, and N through discharge tubes, some tubes being provided with aluminium electrodes and others with carbon electrodes. The spectra were photographed in the first order of a Rowland concave grating of three metres radius. Grating, slit, and camera were mounted on a marble slab. The work was confined to the bands appearing in the near ultra-violet, and the plates were examined by a registering photometer on the principle of that of Moll. The bands of the gases named were photographed when various additions of argon or iodine vapour were made to the gas in the discharge tube. The resulting effect upon the bands is shown by the photometer records, a number of which are reproduced and fully discussed, particular attention being given to the bands of CN and N. Variations in the cyanogen spectrum seem in most cases to be irregular, any regularities being masked by interference by the argon or iodine added. Argon increases the fineness of the lines in the 3884 band and considerably modifies their relative intensity. The effect of iodine vapour depends greatly upon the proportion present. In the case of nitrogen there is no interference by the added argon or iodine and so regular variations are produced. Argon produces a regular decrease of intensity of the component lines, while at the same time doublets replace single lines and triplets replace doublets. It is more difficult to note the effect of increasing proportions of iodine vapour owing to the continuous iodine spectrum.

F. S.

507. *Chemical and Spectroscopic Properties of Excited Atoms and Reversible Effects of Electron Impacts in Gases.* **K. T. Compton.** (Optical Soc. of America, J. and Rev. Sci. Inst. 7. pp. 955–971, Nov., 1923.)—A series of papers, presenting a new and suggestive conception of certain effects of collisions of electrons with gas molecules, has recently appeared in the Zeits. f. Physik, and the present paper is the result of a request to the author for a summary of these to be presented to the Committee of the National Research Council on "Ionisation potentials and related subjects." The first section deals with "*excited atoms*," and attention is called to the accumulating evidence that normal atoms and those which are "excited" by the displacement of an electron to an outer orbit may have very different physical, chemical, and spectroscopic properties. Thus all atoms, even the inert atoms like helium, are electro-negative when excited and tend to form homopolar and heteropolar compounds and negative ions. These compounds and ions are often sufficiently stable to exist for some time in a discharge tube. In any case, they profoundly affect the spectrum of the substance. The next section deals with the *reversible effects of impacts*. Klein and Rosseland point out reasons for believing that an excited atom may revert to the normal state by transferring its energy to a free electron at a collision as well as by radiation. Franck points out that such radiationless transfers of energy may also occur at a collision between an excited and a normal atom. The final section considers *phenomena due to radiationless transfers of energy*. Franck and Cario show that such transfers of energy may account for (1) the quenching of fluorescence by foreign gases, (2) the excitation of the spectrum of one metal vapour by resonance radiation of another vapour which is mixed with it, (3) the dissociation of hydrogen by mercury 2536 Å-radiation when mercury-vapour is mixed with the hydrogen. These suggestions are critically reviewed. H. H. Ho.

508. *Are Quanta Unidirectional?* **G. Breit.** (Phys. Rev. 22. pp. 313–319, Oct., 1923.)—*Theory of the Brownian Motion of a Planck Radiator.*—In the case of a classical resonator it is shown that the motion takes place even though the emission and absorption is not unidirectional, provided the radiation is not strictly monochromatic. This theory is then extended to the case of a quantised atom. Interference between the waves emitted by the atom and the surrounding radiation provides for the recoil actions without the assumption of unidirectional quanta. Statistically these have the same effect as Einstein's unidirectional quanta. This theory removes the contradiction postulated by Einstein between the Rubinowicz-Sommerfeld considerations and the requirements of classical Brownian motion. It leaves the wave-theory of light intact and is in agreement with Bohr's principle of correspondence. AUTHOR.

509. *Absorption Spectra and Molecular Phases. Part I.* **R. A. Morton** and **H. Barnes.** (Chem. Soc., J. 123. pp. 2570–2572, Oct., 1923.)—Baly's conception of molecular phases greatly simplifies the interpretation of absorption spectra, each molecule being regarded as characterised by a definite amount of energy, this molecular quantum being the fundamental quantity governing every reaction of the molecule. Hence since energy can only be exchanged in quanta, the molecule may exist in a number of phases, each consecutive phase differing in energy content by one molecular quantum. Every molecule therefore exhibits a characteristic frequency, usually in the infra-red, and also a phase frequency, usually in the visible or ultra-violet spectrum; the observation of the maximum absorption frequency gives the frequency characteristic of one molecular phase.

Spectroscopic study of three isomeric methoxy – 2 : 3 – dimethylchromones showed that the exhibited in neutral alcoholic solution a single absorption band [Abstract 900 (1922)]. In a table showing the frequencies at which the absorptive power is a maximum, the differences between successive frequencies is a multiple of a fundamental frequency, itself independent of the position of the methoxyl group. Thus, correlation between three factors, isomerism, quantitative energy relationships and differences in reactivity, is obtained in support of Baly's theory. The absorption spectrum of 2 : 3 dimethylchromone showed similar relationships between bands in the ultra-violet which give approximately the same value for the fundamental wave-length. W. V. M.

510. *Solar Radiations in the Remote Ultra-Violet.* **P. Lambert, G. Dejardin,** and **D. Chalonge.** (Comptes Rendus, 177. pp. 757–759, Oct. 22, 1923.)—Fabry and Buisson have shown that from 3900 Å. to 2900 Å., the solar radiations correspond to those from a black body at 6000° Abs. Assuming this to hold good in the remote ultra-violet, the remote ultra-violet should carry $\frac{1}{24}$ the whole energy. From 2900 Å. to 2100 Å. this would be cut off by the ozone in the air, equivalent to a layer 3 mm. thick. From 2020 Å. onwards the radiation would be cut off by the ammonia normally in the air [Duclaux and Jeantet, Abstract 1574 (1923)]. There ought therefore to be a band from 2100 Å. to 2020 Å.; but the authors have failed to find this; at the Mont Blanc observatory. The absorption may be due to oxygen, and investigations into this are proceeding. A. D.

511. *Dispersion Lines in the Spectrum of the Sun's Limb.* **W. H. Julius** and **M. Minnaert.** (K. Akad. Amsterdam, Proc. 26. 5–6. pp. 329–348, 1923.)—The object of this paper is to show that the dispersion theory of the solar spectrum connects quantitatively two, at first sight, independent groups of observed phenomena, namely, the well-established general *widening* of the Fraunhofer lines at the limb, and the increase, also at the limb, of the *mutual influence* of neighbouring lines. This relation proves to be independent of the unknown laws that govern the weakening of any given kind of light on its way through the solar gases; by its means it is possible to indicate an *upper limit* of the mutual influence that may be expected, thus lending fresh support to the fundamental hypothesis. The average value of the mutual influence as deduced from the dispersion theory is found to be perfectly consistent with the actual observations. The dispersion lines which according to the hypothesis of the authors envelop the exceedingly narrow true absorption lines of the solar spectrum arise from two dimming processes, *viz.* irregular refraction and molecular scattering. For although light of any wave-length is subject to refraction and scattering on its long path through selectively absorbing gases, it is well known that these causes of darkening specially affect waves in the immediate vicinity of absorption lines. The following qualitative results are reached: (1) The general but very unequal displacements of the Fraunhofer lines towards the red can be explained by the properties of refraction lines, but not by those of diffusion lines. This also applies to the limb-centre displacements. (2) The mutual influence of neighbouring Fraunhofer lines, which increases as a rule from the centre towards the limb of the solar disk, may be the result of either scattering process; but irregular refraction causes apparent repulsion, molecular diffusion of light gives apparent attraction.

Formulæ are deduced expressing the connection between mutual influence and width of dispersion lines. Assuming that Fraunhofer lines are in the main dispersion lines and starting from data concerning the widening of the lines in the spectrum of the sun's limb, values are derived for the probable increase of the mutual influence in passing from the centre to the limb. These theoretical results are then compared with the data obtained from observations regarding limb-centre displacements of Fraunhofer lines. The theoretical anticipations advanced are consistent with the observational material till now available, but the quantities involved in the investigation are near the limit of precision attainable with existing means of measurement in the solar spectrum. J. J. S.

512. *Rydberg's Formula and Deviating Types of Series.* **G. Wentzel.** (Zeits. f. Physik, 19. 1. pp. 53–66, 1923.)—Under known conditions for the relative sizes of atomic nucleus and series orbit it is to be expected that the first optical series will correspond to the more eccentric orbits. This implies a discontinuous variation of the quantum defect. The conditions mentioned are sufficient to explain series anomalies in certain cases. Such anomalies are to be expected in the principal series of the arc spectrum of Ag and in the diffuse series of the spark spectrum of Cd, but neither of these has been explored hitherto. The best-known example is the P-series of Hg, investigated by Paschen. The paper is mathematical. F. S.

513. *Sensible Fluorescence of Gases.* **J. Franck.** (Phys. Zeits. 24. pp. 450–451, Oct. 15, 1923. Paper read before the Deut. Physikertag., Bonn, Sept., 1923.)—A short note on investigations previously described [Abstract 2410 (1923)]. Before and after the collision of excited and normal atoms definite quantum conditions prevail. At the collision the total available energy of the atoms can distribute itself otherwise by rayless changes. Thus remaining amounts of energy make their appearance as energy of translation or are taken out of it. J. J. S.

514. *Ultra-Violet Resonance Spectra of Iodine.* **O. Oldenberg.** (Zeits. f. Physik, 18. 1. pp. 1–11, 1923.)—Iodine vapour emits a series of lines forming a resonance spectrum when excited either by short ultra-violet radiation or by the green mercury line; in both cases the lines emitted have the same regularity and belong to the same value of the nuclear vibration quantum. There are about 35 lines of longer wave-length, and 5 lines which are of shorter wave-length than the exciting line. This resonance spectrum shades off into the ultra-violet fluorescent band spectrum of McLennan, in the longer wave-length region. Frequencies of many of the lines are represented by

$$\nu = 52630(1 - 0\cdot00416\,n + 0\cdot000017n^2)\text{cm.}^{-1}$$
$$n = 0, 1, 2, \ldots.$$

It is concluded that the band spectrum is an extension of this short wave-length resonance spectrum, and it is also shown that the fluorescence spectra are due to the iodine molecule [see Abstracts 375 (1918) and 443 (1921)]. A. C. M.

515. *The Influence of Crossed Electric and Magnetic Fields on the Spectrum of Hydrogen.* **O. Halpern.** (Zeits. f. Physik, 18. 5. pp. 287–303, 1923.)—A mathematical investigation of the influence of homogeneous electric and magnetic fields perpendicular to each other on the energy values of hydrogen atoms (simple ionised He-atoms). Apart from the spectroscopic interest in the splitting of spectral lines in a combined Stark and Zeeman effect, the problem of the general possibility of a sharp quantelation of a system is considered, *i.e.* whether the resulting spectral lines are sharply separated, or spread out diffusely. Methods of integration are discussed with respect to different types of systems. Epstein [Abstract 1886 (1922)] and Born and Pauli's [Abstract 1955 (1922)] conditions for exact quantelation are considered too far-reaching.

The paper is mathematical throughout and does not admit of a concise abstract. W. V. M.

516. *The Electron Affinity Spectrum of Iodine.* **W. Gerlach** and **F. Gromann.** (Zeits. f. Physik, 18. 5. pp. 239–248, 1923.)—An explanation of the " electron affinity spectrum " as a continuous spectrum given out when electrons fall into electro-negative atoms with varying velocities leads to an account of experiments on the spectrum of iodine in the regions 4800 Å. and 3400 Å. : at 4800 Å., Steubing [Abstract 1440 (1921)] found a rapid fall in intensity in the continuous spectrum, confirmed by the present investigation.

Five series of observations on the emission spectrum of iodine over the region 4800–2700 Å. at temperatures up to 1050° C. and vapour pressures from 0·1 to 10 mm. showed that the intensity of the continuous band ending at 3460 increased with high temperatures and low pressures, *i.e.* high degree of dissociation. The authors conclude that the band 3460–3340 is the electron affinity spectrum of iodine as it conforms to all demands made on such a spectrum. The " electron affinity " of the iodine atom is calculated from the value of the limit of this spectrum by means of the usual quantum relationship and found to be 81·8 ± 0·2 cal./mol. a value agreeing quite well with those obtained in an entirely different manner from considerations of space-lattice theories and electronic bombardment. W. V. M.

517. *Radiation Properties of Aluminium and Magnesium Oxide.* **F. Henning** and **W. Heuse.** (Zeits. f. Physik, 20. 2. pp. 132–144, 1923.)—Very little experimental data exists with respect to the radiation of solid transparent bodies and the dependence of emission capacity on temperature ; hence the present investigation. It is now found that glass, quartz glass, and synthetic water-clear sapphire (aluminium oxide) do not radiate in the visible spectrum. Synthetic ruby (aluminium oxide containing a small amount of chromium oxide), however, possesses between − 100° and ordinary temperatures a fairly sharp absorption in the green, whose maximum lies between $\lambda = 0{\cdot}51$ and $0{\cdot}525\,\mu$. With increasing temperature the absorption quickly broadens, so that at $t = 1100°$ the permeability D of the ruby for the whole visible range depends only slightly on the wave-length. For $t = 1100°$, the absorption maximum lies at $\lambda = 0{\cdot}58\,\mu$. Between room temperature and 1100° the absorption capacity of the ruby rises in the visible region and the more the wave-length observed is from the red end of the spectrum. The reflection capacity R of the ruby experiences much smaller changes with temperature, the sign of its temperature coefficient varying with the wave-length. The emission capacity, $E = 1 - R - D/(1 - R)$, of the ruby is only independent of temperature at the shortest wave-lengths ($\lambda = 0{\cdot}525$) ; for the longer waves of the visible spectrum it increases with temperature the longer the wave. At 1100° a 9-mm. thick layer of the ruby investigated in the visible region, radiated approximately as a grey body of emission capacity 0·8. In the ultra-red, ruby and sapphire possess strong absorption bands beyond $4\,\mu$, which have practically the same values for both bodies. Magnesium oxide which possesses very little emission capacity (0·02) in the visible spectrum, emits considerably beyond $4\,\mu$ and at 1150° attains about 15 % of the radiation of a black body. H. H. Ho.

518. *Absorption Spectra of Solutions of Benzene and Some of its Derivatives at Various Temperatures.* **J. E. Purvis.** (Cambridge Phil. Soc., Proc. 21. pp. 786–789, Nov., 1923.)—The author points out the absence of data on the effects of temperature on the spectra of solutions of organic substances. He has investigated the vapours of a number of organic materials and noticed that narrow bands widen into each other at the higher temperatures and pressures.

Benzene (alcoholic solutions of three strengths), toluene, monochlorobenzene, phenol, aniline, and benzonitrile, were investigated, and the results show that the effect of an increased temperature on solutions of these six substances is a widening of the bands; the edges become more diffuse; there is a slight shift towards the red end; and they are a shade weaker. The effects are similar to those obtained with inorganic substances, and there is no suggestion that benzene, toluene, or aniline are ionised in solution, but the effects of heat on the absorption bands are similar to those on supposedly ionised inorganic salts. The fundamental vibrations of the simpler substances are modified by the type of atom or group of atoms which may be introduced into the molecule. W. V. M.

519. *Carbon Arc Spectrum in the Extreme Ultra-Violet,* II. **F. Simeon.** (Roy. Soc., Proc. 104. pp. 368–375, Oct. 1, 1923.)—An extension of work referred to in Abstract 1145 (1923). A grating ruled at the National Physical Laboratory was employed having a ruled area 5 × 3·6 sq. cm., and 100 cm. radius of curvature; there being 568 lines per mm. Wavelengths down to 360 Å. were measured. The spectrum of the carbon arc *in vacuo* extends as far in the extreme ultra-violet as the spark, except for a weak line at 360·5 Å. By this investigation 25 new lines are added to the arc spectrum. Assuming that the limit of the L series for carbon is 360 Å., from the relation $Ve = h\nu$, V should be approximately 35 volts. It was found that the arc could be maintained at this potential, and photographs of the spectrum were taken, and compared with photographs taken with higher voltages. It is concluded that the lines visible with 30 volts applied to the electrodes were due to the arc spectrum of carbon, with the exception of five lines, which were all "short lines." A. C. M.

520. *Changes in a Helium Spectrum-Tube.* **A. F. Miller.** (Roy. Astron. Soc. Canada, J. 17. pp. 322–324, Oct., 1923.)—The spectrum of a tube originally showing helium and faint hydrogen lines gradually changed to that of CO_2. When, however, this tube was simultaneously excited by the same coil as a second tube containing pure helium, the helium spectrum gradually but completely replaced the CO_2 spectrum. When excited alone, the first tube again gave the CO_2 spectrum. The second tube had no effect on tubes originally filled with CO_2. The effect is attributed to resonance. F. S.

521. *Excitation Stages in the Open Arc-Light Spectra. Part III. Lead, Mercury, Thallium, Magnesium.* **B. E. Moore.** (Astrophys. J. 58. pp. 86–103, Sept., 1923.)—In the present study photographic methods were used in contrast to visual methods of the previous studies. It is found that the true arc begins to discharge from a minute point or negative polar tip. This tip discharge never forms without ionisation; and when the pole is a bivalent element there are always lines belonging to the Rydberg 4N limit, lines which are theoretically associated with a return of the second valence electron to the nucleus, *i.e.* at the pole tip the temperature and velocities of the electrons are always high enough to produce appreciable dissociation of the atom. For the element *lead* all the observed lines are easily produced and show an exceptionally low ratio of pole to middle intensity. This indicates that the lines belong to Stage I and that there is an appreciable amount of lead vapour in the arc at low currents. Two stages are found in the development of the lines of *mercury* and a possible third stage is suggested; furthermore, the lines develop more slowly than in the other metals. Two stages are found in the development of the lines of thallium. There are four stages in the development of the lines of *magnesium*, which correspond closely to what is known from other considerations as a resonance, first ionisation, a subsequent resonance, and a second ionisation. The changes are subtle and the stages overlap. The different actions of nitrogen and hydrogen atmospheres are used in these experiments. Enhancements are carefully considered, and evidence is given confirming the opinion, which has been frequently contested, that the enhanced lines correspond to hotter stages. AUTHOR.

522. *Excitation Stages in the Open Arc-Light Spectra. Part IV. Hydrogen, Air, Water-Vapour, Pressure Effect, Mixed Electrodes.* **B. E. Moore.** (Astrophys. J. 58. pp. 104–112, Sept., 1923.)—*Effect of the Medium (Hydrogen, Air, Water-Vapour) upon the Spectrum.*—If hydrogen is substituted for air or nitrogen the middle of the arc is cooler, but it is hotter at the electrodes because of the increased polar drop of potential; and there is a corresponding effect upon the spectra of the electrode materials. The many-lined spectrum of hydrogen is more easily excited than the Balmer series. These lines have two features in common with air bands, nitrogen bands, certain chloride bands, and a large group of water-vapour lines, all of which were examined, *viz.* they are all easily excited, and they form only on the outside of the hot polar discharge. The inference is that the products which produce these types are dissociated by high heat.

Effect upon the Spectrum of Pressure and of Mixed Electrodes.—Decreased pressure is accompanied by a decrease in temperature and results in less contrast in the series lines. The spectral lines appear first at the negative pole, even when the substance in question is located at the positive pole. A low-volatilising substance at the positive pole increases the intensity of the spectrum in the middle of the arc of a higher volatilising substance used as a negative electrode. This is attributed to the vapour of the positive pole which conserves the heat in the middle of the arc and raises the temperature. As the vaporised electrode material increases in the arc it progressively suppresses the hydrogen spectrum. The effect begins at a lower current with an easily volatilised substance, *e.g.* cadmium, than it does with a substance which volatilises at a higher temperature, such as copper.

General Conclusion.—The changes due to pressure and temperature together with the variations in electron velocity are sufficient to explain all the differences which have been noted in the spectra. AUTHOR.

523. *Stages in the Excitation of the Spectra of Thallium.* **F. L. Mohler** and **A. E. Ruark.** (Optical Soc. of America, J. and Rev. Sci. Inst. 7. pp. 819–829, Oct., 1923.)—Evidence for the assignment of orbits suggested by Bohr for the elements Al, Ga, In, and Tl is given in a study of the absorption spectra of Tl and In by Grotrian [Abstract 907 (1923)]. Direct test of the theory by a measurement of the critical potentials for thallium proved full accord between the two if it is assumed that $2p_2$ is the normal orbit of the third valency electron.

Critical potentials of thallium vapour have been measured, with the following results—first resonance potential at 0·9 volt, first ionisation potential 6·04 volts. A higher critical potential detected by the photoelectric effect of the radiation is at 12·4 volts. Spectroscopic results were as follows: Thallium spectra at 7 to 10 volts show the first arc spectrum. All the lines of these spectra are classified as arc lines and belong to the doublet series system, successive lines of the two subordinate series appearing with increasing voltage. Above 12 volts another line spectrum appears nearly as strong at 14 volts as at 20. This is evidently associated with the 12·4 volt critical potential. Comparison of the critical potentials with the doublet system of thallium, shows that the first ionisation potential is determined by the limit $2p_2$ and the first resonance potential by the difference $2p_2 - 2p_1$. This transition $2p_2 \longrightarrow 2p_1$ is also accomplished by thermal excitation above 800° C. Since no radiation can result from this transition the orbit $2p_1$ must be meta-stable.

Resonance potentials corresponding to frequencies $2p_2 - ms$ and $2p_2 - md$ give rise to the observed low-voltage spectra. Corresponding critical potentials are calculated for Al, Ga, and In. The spectrum lines appearing above 12·4 volts are mostly classified as enhanced in the spark and are ascribed to a second type of single ionisation, the removal of one of the two, 6_1 electrons. The transition of the 6_2 electron into the vacant 6_1 orbit is discussed and found not to be forbidden by selection principles for the azimuthal numbers or the " grund " numbers. W. V. M.

524. *Absorption Spectra of Some Organic and Inorganic Salts of Didymium.* **J. E. Purvis.** (Cambridge Phil. Soc., Proc. 21. pp. 781–785, Nov., 1923.)—Merton [Abstract 1017 (1911)], from a study of the absorption spectra of permanganates, concluded that the general nature of the absorption is due to the grouping MnO_4 and is influenced very little by the nature of the kation or the extent of the dissociation. Liveing (Trans. Camb. Phil. Soc. 1899. 18. 298) concluded from a series of observations that the characteristic absorptions of didymium which are only modified by concentration, heat, and variation of the solvent, are due to molecules which are identical in all cases.

The author has investigated the absorption of didymium-phenyl-acetate and compared it with the absorption of equivalent amounts of acetate, chloride, and nitrate of didymium, and also phenyl-acetic acid itself.

The results indicate that in the visible regions, various bands of didymium show slight differences according to the nature of the acid radicle. The differences are more apparent in the acetate and phenyl-acetate particularly at λ596, 590–570, and λ476. In the ultra-violet regions the differences are much more marked. It is concluded that the anions and kations of the molecule do not vibrate independently of each other.

Didymium is not a single element and the various salts of the constituents would differ in their absorptive capacities, the results observed being the effects of a complex series of vibrations of electrons, atoms, and molecules. W. V. M.

525. *Series Spectra in Oxygen and Sulphur.* **J. J. Hopfield.** (Nature, 112. pp. 437–438, Sept. 22, 1923.)—Results are obtained confirmatory of those previously reported and called in question. Sulphur spectra are examined for the first time in the region shorter than 2500 Å. In oxygen, two series are extended to seven and six members, respectively, while the third series remains with one member only. The wave members of the head OP_{123} of the new triplet series are 109833, 109674, and 109607. For sulphur, dry SO_2 was used at various pressures in the receiver and in the connected discharge-tube of the vacuum grating spectrograph. SO_2 gas has two strong absorption bands, from λ2500 to λ1700, and λ1650 into the u.v. indefinitely, there being a relatively transparent region in between. Using low pressures, strong spectra have been obtained, even in the absorption regions. The spark spectrum consists of many lines, and groups of lines down to λ350. The arc spectrum contains a number of wide triplets having constant frequency difference. These triplets are classified into series analogous to those in oxygen.

Both the oxygen and sulphur spectra have characteristics in common, *viz.* the separations and intensities of the triplets are inverted compared with their spectra in the visible and infra-red. Assuming the level OP_{123} to be the valence level, the resonance and ionisation potentials are: Oxygen, 9·11, 13·56 v.; sulphur, 6·50, 10·31 v. respectively. A. C. M.

526. *Critical Potentials of the Thorium M-Series Lines.* **P. A. Ross.** (Phys. Rev. 22. pp. 221–225, Sept., 1923.)—Spectrograms taken with various potentials decreasing in steps from 10 kv. to 3·2 kv. are reproduced which show six lines, α to ϵ of Stenström and a *new line* ϵ_2 of wave-length 2·85 Å. By use of screens made of tissue paper soaked in thorium nitrate, five absorption limits, M_1 to M_5, were found, checking the results of Stenström and Coster. The *critical potentials* of the six lines were determined and found to agree with the values predicted by the quantum law from the corresponding absorption limits M_1 to M_5, both δ and ϵ_1 corresponding to M_4, and ϵ_2 to M_5. A *vacuum X-ray spectrograph* is described in which a screen with a slit is rotated in front of the plate at twice the angular speed of the crystal so as to prevent scattered rays from striking the plate. AUTHOR.

527. *Vacuum Grating Spectrograph and the Zinc Spectrum.* **R. W. Wood.** (Phil. Mag. 46. pp. 741–750, Nov., 1923.)—Published reproductions of spectrograms obtained with vacuum grating spectrographs show that higher resolving power is much to be desired. A three-fold enlargement of a spectrogram of zinc obtained with a grating specially ruled on the Rowland engine is given, together with reproductions of certain groups enlarged 7·5 times, and small regions of these enlarged 34 times. A ruling was chosen not much lighter than those usually employed which gave a light brown colour in the central image. The radius of curvature of the plate was one metre, and it was ruled with 15,000 lines to the inch, the ruled surface measuring about 1 × 4 inches. The source of light was the intermittent arc-like discharge between metal beads if a source of high potential with a spark-gap is included in the circuit, an arrangement which was described by the author in 1897 and since used by Millikan in his well-known work. A 30,000-volt transformer with two large Leyden jars and a spark-gap of about a centimetre was used, about

1000 flashes giving a fully exposed plate in about twenty minutes. With a grating of only one metre radius a very fine slit must be employed, and the focus determined to within 0·5 mm. It does not appear as if anything could be gained by the use of a bent plate. In the region between $\lambda = 1283$ and $\lambda = 1500$ are recorded 96 lines as against 14 in Sawyer's table. The wave-lengths are based on Simeon's values for carbon [see Abstract 1145 (1923)] and an accuracy of 0·05 Å. is expected. Tables are given for the ranges 1600 to 1930 and 830 to 1300, and the values discussed. Lyman ghosts were obtained between 1200 and 2000 when adjusting the grating with the aluminium spark. No trace was obtained with visible light or Hg 3660, and only a faint trace with Hg 2536. A further study is promised. F. S.

528. *Term Structure and Zeeman Effect of Multiplets. Part II.* **A. Landé.** (Zeits. f. Physik, 19. 2. pp. 112–123, 1923.)—In Part I [see Abstract 1863 (1923)] it was shown that the series terms of multiplets were characterised by 3 quantum numbers R, K, J, to which a fourth must be added in the magnetic field. Now it is established that for the theoretical proof of the Paschen-Back effect, not only must the transformation of the resolving factors g be considered, but also that of the interval factors ν. The normalisation of g according to Pauli, employing Heisenberg's permanence of the g-sums, shows that in a strong field the mechanics for the stationary quantum states is valid to a greater degree than in a weak field where the inner coupling prevails. In order to derive the term-interval rule, the interval factors ν are calculated for the strong field (with R, K, J as basis for the model representation), and then the transformation to the weak field is completed by utilising the permanence of the ν sums. The two permanence demands are due to the conservation of the turning moment which every group of term components with common m possesses relative to the centre of inertia of the multiplet. The centre of inertia of the term multiplet is then preserved on passage to a strong magnetic field: $\sum_{J,m} mg \equiv 0$, and $\sum_{J,m} \nu \equiv 0$. Based on these permanence principles, a simple method for the calculation of fieldless term energies has been proposed as a substitute for the invalid mechanics of coupled systems. H. H. Ho.

529. *The Quantum Theory of the Normal Zeeman Effect.* **O. Halpern.** (Zeits. f. Physik, 18. 6. pp. 352–358, 1923.)—The quantum theory of the Zeeman effect, when based on the mechanical model conception and with the aid of the correspondence principle, leads to the classical Lorentz triplet. This result is correct, however, so long as quadratic terms are neglected in the magnetic field strength. When the latter are included, then the results are essentially changed. Reference is made to work on this subject by Herzfeld, Sommerfeld, and Debye [see Abstract 54 (1917)]. The quadratic terms have the effect of making the Hamilton-Jacobian differential equation of the initial system no longer separable and so appear to render a solution of the problem inaccessible. Debye, however, has pointed out how important are the quadratic terms for the question of the validity of the quantum theory, and since the applications of the theory of secular positions by Bohr, a means has been afforded for carrying out the integration. The present paper now gives the theoretical treatment of disturbed systems and the influence of disturbance upon the hydrogen spectrum. The Hamilton function of the disturbed system is first derived, then a discussion of quantum states, and finally applications to the hydrogen spectrum. H. H. Ho.

530. *Zeeman Effect of H_α and H_β.* **K. Försterling** and **G. Hansen.** (Zeits. f. Physik, 18. 1. pp. 26–33, 1923.)—H_α and H_β are normally each a doublet. The authors find that in a magnetic field, each of the pair forming H_α give rise to three components, forming thus a pair of Zeeman triplets. But the triplets do not remain in the positions of the original components; they approach each other, and for very strong fields form what is practically a single triplet. This effect is unintelligible on any present theory of the Zeeman effect. Similar results hold for H_β. In this behaviour the hydrogen doublets behave as those of sodium and lithium, forming a single normal Zeeman triplet in fields of the order of 20,000 gauss [see Abstract 684 (1923)]. A. C. M.

531. *A Determination of e/m from Measurements of the Zeeman Effect.* **H. D. Babcock.** (Astrophys. J. 58. pp. 149–163, Oct., 1923.)—Forty-nine separate values were derived from spectroscopic observations of the Zeeman effect, with absolute measurements of the magnetic field-intensity. About 40 lines in the blue region of the chromium spectrum were most frequently used. These were supplemented by 76 other lines of chromium, titanium, zinc, and barium. At field-strengths averaging about 30,000 gausses the separations of these lines were measured for the derivation of the normal separation, *a*. A wide variety of types of separation was used, but most dependence was placed on lines known to have small denominators in their fractional relation to *a*. Field measurements were made with ballistic galvanometer, test coil, and mutual inductance, in the primary circuit of which a known current could be reversed. The uncertainty affecting each factor in the working equation is discussed and the combined effect of all upon the result is derived. The chief difficulty in this method is the determination of *a*, the only other source of appreciable error being the magnetic area of the test coil. The final result from all the observations is $e/m = 1{\cdot}761 \times 10^7$, with a probable error of one part in 1800 and an estimated actual uncertainty of 2 or 3 parts in 1800. AUTHOR.

532. *Wave-Length of Scattered X-Rays.* **H. Kulenkampff.** (Zeits. f. Physik, 19. 1. pp. 17–19, 1923.)—According to the observations of Compton [see Abstract 2198 (1923)], the wave-length of X-rays is altered with scattering. An explanation was given by Compton and independently also by Debye [see Abstract 1878 (1923)]. Experiments are now described which seem to indicate that the wave-length of the rays are not altered by reflection at a crystal. It is, however, considered that there is no ground for doubting the correctness of the results obtained by Compton. A. E. G.

533. *A Direct Reading X-Ray Intensimeter.* **P. Lertes.** (Zeits. techn. Physik, 4. 9. pp. 317–321, 1923.)—Describes and illustrates an instrument for measuring X-ray dosage which has an advantage over the ionoquantimeter apparatus, since a direct reading is given upon a galvanometer. Briefly this consists of an ionisation chamber which is exposed to the radiation and the ionisation current is applied to the grid and filament of a thermionic valve which intensifies the current to enable it to give a direct reading on a milliammeter in the valve plate circuit. A variable resistance is placed across the grid circuit to compensate the reading due to the ionic flow from filament to grid when the ionisation chamber is unexposed to X-radiation. The practical difficulties encountered in applying the valve to this purpose are dealt with at length and the somewhat bulky apparatus is illustrated. Precautions have to be taken to shield the valve from the direct action of the X-rays. The calibration of the instrument is described. B. J. L.

534. *Absorption Measurements of the Change of Wave-Length Accompanying the Scattering of X-Rays.* **A. H. Compton.** (Phil. Mag. 46. pp. 897–911, Nov., 1923.)—In previous papers [see Abstract 2194 (1923)], it has been shown that X-rays of wave-length 0·708 and 0·630 Å. suffer a change of wave-length when scattered from graphite. A quantum theory of the phenomenon has been evolved which generally predicts such a change. Experiments with γ-rays confirm the theory, whereas scattering of light by paraffin wax has failed to do so. Hence the effect would appear to be dependent upon wave-length. The present experiments are intended to test the theory over a wider range of X-rays, with a greater variety of scattering media.

A theoretical relation $v_\theta = v_0\{1 + \alpha(1 - \cos\theta)\}$ is evolved where $\alpha = hv_0/mc^2 = h/mc\lambda_0$ with the usual nomenclature. The experimental method is described in detail. This is a balance method in which two beams from a Coolidge tube pass into two ionisation chambers one beam being scattered by a radiator. One ionisation chamber is kept at a positive potential and one chamber at a negative potential, so that no deflection of the electrometer occurs if the ionisation is equal in both chambers, and a graph of the deflection is obtained if this is not the case. The relation of the ionisation ratio of the two chambers is connected with the coefficients of absorption of absorbing screens placed alternatively over the inlet of the two chambers and this allows comparison of the values of μ and therefore of the wave-length. The experimental results are given in detail for the following scattering media: paraffin, paper, Al, Fe, Sn, Pb, Cu, with observed wave-length changes over a region 0·7–0·024 Å. For light elements and short wave-lengths the variation of wave-length is very near the theoretical value, but is below this value for long wave-lengths and heavy elements. It appears probable that in each case the scattered ray consists of two portions, an unmodified ray and a modified ray. The effective wave-length change depends upon the relative distribution of energy between these two constituents, and in optics the unmodified ray predominates and therefore the scattering effect is small. The presence of the unmodified ray may be accounted for by the light quanta not being sufficiently great to eject the firmly held electron from a heavy atom, but experiment does not confirm this view. An alternative explanation is based upon the scattering of the energy by two or more electrons which give rise to interference effects with negligible wave-length change, and experiment appears to show that the unmodified ray results from scattering by groups instead of single electrons. The limb effect, or difference in wave-length of solar lines between the centre and limb of the photosphere, receives a satisfactory qualitative explanation on the view that it is due to a change of wave-length as the light is scattered by an electron atmosphere around the sun. B. J. L.

535. *Scattering of X-Rays by Light Elements.* **G. E. M. Jauncey.** (Phys. Rev. 22, pp. 233–241, Sept., 1923.)—In Compton's recent theory [see Abstract 2194 (1923)] of the scattering of X-rays in separate quanta, a definite change in wave-length due to scattering is predicted; but in order to calculate the intensity of the scattered beam a non-rigorous argument is employed from analogy with the Doppler effect. In the present paper it is shown that the energy removed from the primary beam is of the order of magnitude of the energy falling on a sphere of the radius of the electron. It is therefore assumed that quanta of X-rays in the form of corpuscles are deflected by the electrons according to a law of force such that for corpuscles of small momentum (low-frequency quanta), the distribution of the scattered rays is that expressed by the classical theory. It is found that for corpuscles of large momentum (high-frequency quanta) the scattering electron recoils on collision in such a manner that the distribution of the energy of the scattered rays is modified. Curves and formulæ are given showing for different radiation frequencies the theoretical values of the total energy removed from the primary beam by scattering, the energy which re-appears in the scattered beam, and the energy of recoil in the scattering electrons. The formula expressing the distribution of the scattered X-rays is similar in form to that obtained by Compton, but gives appreciably different results for very high-frequency radiation such as hard γ-rays.

A. B. W.

536. *Continuous Spectral Energy Distribution within the X-Ray Tube.* **P. Kirkpatrick.** (Phys. Rev. 22. pp. 37–47, July, 1923.)—The continuous spectral energy distribution of X-radiation as emitted from the target of a Coolidge tube at right angles to the beam of electrons, has been determined from the distribution curve obtained with a rock-salt crystal spectrometer and a methyl iodide ionisation chamber, by applying the following corrections: (1) For superposed high orders (determined from polychromat curves, and also from the absorption of the complex rays in aluminium); (2) for incompleteness of absorption in the ionisation chamber (determined by absorption experiments); (3) for absorption by glass wall, by air, and by aluminium window (determined by observation or by computation); (4) for reflecting power of the rock-salt crystal (obtained from curve derived from results of various investigators). The final curves show maxima at 0·445 and 0·503 Å. for 71 and 51 kv. respectively. Comparison of these curves with those given by the theories of Behnken, March, and Davis, shows agreement with none. The maxima correspond to the equation $\lambda_m = k + k'\lambda_0$ where λ_0 is the quantum wave-length. The production of constant potential X-ray spectra with alternating voltage by use of a synchronous shutter between the tube and spectrometer is described.

A. B. W.

537. *Ultra-Violet Fluorescence Excited by X-Rays—Spectrographic Study.* **J. O. Perrine.** (Phys. Rev. 22. pp. 48–57, July, 1923.)—(1) *Ultra-Violet.*—In order to photograph the spectrum, the specimen being studied was placed in front of the slit of a Fuess single-prism quartz spectrograph and was exposed to X-rays from a Coolidge tube with the target about 12 cm. away. With the tube operating at 0·002 amp. and 50 kv. and a slit width of 0·15 mm., exposures up to 15 hours were made. Over one hundred substances were tested. Fourteen double salts of uranium, 23 oxides, 50 other compounds, and also anthracene, chrysoidine, eosin, and fluorescine gave no ultra-violet fluorescence, though some show brilliant bands in the visible spectrum; but positive results were obtained with the chlorides of Cd, Cs, Li, K, Na, and Rb, and also with KBr, KI, $BaSO_4$, $RaSO_4$, and $CaWO_4$. NaCl gave a strong band with a maximum at 2470 Å., and CsCl gave a band extending from 5720 to 2340 Å. with three maxima. Several willemite screens, X-ray intensifying screens, and one fluoroscopic screen also showed ultra-violet fluorescence.

2. *Visible Fluorescence.*—One or more bands in the visible spectrum were emitted by all the salts showing ultra-violet fluorescence, except barium and radium sulphates, and also by ZnO, CdI, Cu_2I_2, HgCl, and by the uranyl salts.

Changes of colour were observed when certain chlorides were exposed to X-rays.

A description is given of a photoelectric photometer for measuring distribution of intensity in the spectrograms. A. B. W.

538. *The Reflection of the Characteristic Röntgen Rays of the Chemical Elements of a Crystal by Means of the Latter.* **B. Walter.** (Zeits. f. Physik, 20. 5. pp. 257–271, 1923.)—Recently Clark and Duane made the remarkable observation [see Abstract 2202 (1923)] that in the spectrum obtained according to the Bragg method with crystal and ionisation chamber, not only were the lines of the anti-kathode metal of the tube obtained, but also those of the chemical elements of the crystal and with about the same intensity. These experiments were carried out with crystals containing Br, I, and Cs. The present author describes in detail a comprehensive experimental investigation of the phenomenon in which the crystals lines of Clark and Duane were found to be too feeble for measurement, and he cannot account for the discrepancy. In addition, the spectra of Clark and Duane exhibit on the long wave side of the absorption bands of the elements named a very steep falling away which is not present in the author's spectra and, which, according to current information as to the course of the intensity in the continuous spectrum of a Röntgen tube, does not correspond with reality. H. H. Ho.

539. *The Effect of a Magnetic Field on the Absorption of X-Rays.* **J. A. Becker.** (Phys. Rev. 22. pp. 320–323, Oct., 1923.)—A continuation of previous work [Abstract 170 (1923)] with improved specimen holders and technique. *Iron, aluminium, and carbon* showed no changes in the absorption coefficient as great as one part in 10,000 (due to a magnetic field of 17,000 gauss) when the tube was operated at 90 kv. peak. *Carbon, wood, and lithium* also showed effects smaller than the limit of accuracy of the apparatus—2 parts in 10,000 for 61 kv., 4 parts in 10,000 for 46 kv., and 10 parts in 10,000 for 30 kv. If the effect exists, then, it is very small. AUTHOR.

540. *An Experimental Check of the Optical Theory of X-Ray Reflection.* **P. Kirkpatrick.** (Phys. Rev. 22. pp. 414–419, Nov., 1923.)—*Absorption Coefficient.*—The effective absorption coefficient of rock salt for first order (100) reflected X-radiations has been determined from a study of transmission reflection as a function of crystal thickness, according to the method of Bragg, James, and Bosanquet, for five wavelengths between 0·24 Å. and 0·59 Å. The results are well represented by the equation $\mu = 189\lambda^{2 \cdot 9} + 0 \cdot 43$, where λ is in Ångström units. The secondary extinction coefficient, due to irregularities of the crystal, was also obtained by subtracting the ordinary absorption coefficient μ_0 from μ, and was found to conform to the equation $\epsilon = 190\lambda^{4 \cdot 6}$. The primary extinction coefficient was assumed to be negligible.

Variation of the X-Ray Reflecting Power of (100) *Rock Salt for First Order, with Wave-Length.*—For this simple case, the Darwin-Bragg equation, based on optical theory, reduces to: Reflection coefficient $= \text{const.} \times \lambda^2(1 + \cos^2 2\theta)/\mu \cos\theta$. Using the experimental values of μ, the theoretical variation with λ is found to be much more rapid than that indicated by experimental data given by various other observers. Possible reasons for this discrepancy are suggested. AUTHOR.

541. *The Value of c in the Relation* $\mu/\rho = c\lambda^3 + k$. **K. A. Wingårdh.** (Zeits. f. Physik, 20. 5. pp. 315–316, 1923.)—In a previous paper (Dissertation Lund, 1923) the author obtains the relation $\mu/\rho = c\lambda^3 + k$ connecting the absorption coefficient μ/ρ with the wave-length λ for short wave-length X-rays ($0 \cdot 156$ to $0 \cdot 254 \times 10^{-8}$ cm.). The values of c for different elements were determined and are given in the second column of the table below. In the present paper another method of calculating c is given and the results, shown in column 3, found to agree well with those previously obtained.

Element.	c.	
	1.	2.
Al	15·6	15·5
Co	136	134
Cu	169	165
Zn	200*	183
Ag	660	687
Sn	780*	825

* Approximate only.

The quantity c is shown to be proportional to $Z^{2 \cdot 95}$ where Z is the atomic number of the element. A. B. W.

542. *Polarisation of X-Rays as a Function of Wave-Length.* **P. Kirkpatrick.** (Phys. Rev. 22. pp. 226–232, Sept., 1923.)—(1) *As a Function of Wave-Length.*—Rays from a Coolidge target were caused to fall upon a block of paraffin, and the relative intensities of the secondary rays scattered in a plane normal to the primary rays and in directions respectively parallel and perpendicular to the primary kathode rays, were determined by ionisation chambers connected to string electrometers. In a qualitative way, the polarisation was shown to be greater for the shorter wave-lengths, by the effects of various filters; also the secondary radiation was found more penetrating in the direction of maximum scattering than at right angles. Quantitative results were obtained from the observed changes in the total primary polarisation as the form of the spectrum curve was changed in a known manner by the insertion of absorbers in the primary beam. For a maximum voltage of 56 kv., the ratio of components increased from 0·835 at 0·3 Å. to 0·98 for 1 Å. Thus even the shortest wave-lengths (0·22 Å.) were not completely polarised. (2) *As a function of voltage*, the mean polarisation decreased as the maximum voltage increased from 26 to 64 kv., the corresponding component ratios increasing from 0·77 to 0·92. The results indicate that even for a very thin target the polarisation would decrease as the kathode-ray velocity increased. AUTHOR.

543. *Filtration of X-Rays.* **P. Lamarque.** (Arch. d'Él. Médicale, 31. pp. 297–312, Sept., and pp. 321–324, Oct., 1923.)—After dealing with the laws of absorption and emission of X-rays, the author discusses the various methods of filtering X-rays (by the use of metal screens) for medical purposes. A. B. W.

544. *Anomalous Reflection of X-Rays in Laue Photographs of Crystals.* **R. W. G. Wyckoff.** (Am. J. Sci. 5. pp. 277–287, Oct., 1923.)—Spectroscopic observations by Clark and Duane [Abstract 2202 (1923)] have pointed to the existence of intense diffraction effects which could not be explained as "reflections" from any imaginable atomic planes. The positions of these "X-peaks" have been defined by these authors for various angles of diffraction. With the experimental methods now described it has not been found possible either to reproduce the published Laue photographs or to find any evidence for the existence of X-peak diffractions in crystals of potassium iodide. It is made clear that no anomalous effects are discernible. Hazy diffraction effects, probably arising from a distortion in the crystalline arrangement, have, however, been observed and briefly described. The data from these Laue photographs are in complete accord with the previously assigned "sodium chloride arrangement" of the atoms in crystals of potassium iodide. A. B. W.

545. *Diffusion of X-Rays and Bragg's Law.* **F. Wolfers.** (Comptes Rendus, 177. pp. 759–762, Oct. 22, 1923.)—The departures from Bragg's law can be explained in a manner compatible with the theory of quanta, if we assume that diffusion in a crystal is of the same nature as in any other body. A. D.

546. *Crystal Powder Analysis by X-Rays.* **J. Brentano.** (Nature, 112. pp. 652–653, Nov. 3, 1923.)—For the purpose of making more accurate comparative intensity measurements by the photographic powder method (Debye and Scherrer, Hull, Seeman, Bragg, and others), and also of obtaining sharper lines without recurring to long exposures, an arrangement has been tried in which a thin layer of powder and a beam of greater angular width are used. The author states that a more complete description of the apparatus will be given elsewhere. A. B. W.

547. *The X-Ray Examination of Metals.* **W. J. Wiltshire.** (Röntgen Soc., J. 19. pp. 155–162, Oct., 1923.)—For examining large specimens of metal for flaws on a routine basis, penetrating radiations with high voltages and a considerable current are required, and apparatus which can work continuously all day. Scattering in the metal itself, in the photographic plate, and in the intensifying screen, if this is used, is of the greatest importance. A great deal of radiation comes from other parts of the tungsten target of a Coolidge tube besides the focal spot, and this interferes with good definition; two diaphragms with very small apertures may be used to cut off the disturbing rays, greatly improving matters. In the Research Department at Woolwich Arsenal fluorescent screens are sometimes employed, viewed by means of a mirror, so as to avoid injury by X-rays; but for many purposes the images are radiographed on radio-print paper, as many as 2000 articles being examined per day with one X-ray outfit. H. N. A.

548. *L-Series Absorption Spectra of the Elements La* (57) *to Hf* (72). **D. Coster, Y. Nishina,** and **S. Werner.** (Zeits. f. Physik, 18. 3–4. pp. 207–211, 1923.)—Results are given of a determination of the absorption constants in the L-series of the series of elements La to Hf. These results explain certain discrepancies observed by Bohr and by Coster in the "Niveau" curves in the region of the rare-earths. A. B. W.

549. *Intensity of X-Ray Spectrum-Lines at High Voltages.* **G. Kettmann.** (Zeits. f. Physik, 18. 6. pp. 359–371, 1923.)—A description is given of a method of photographic intensity measurement of X-ray spectrum lines. Intensity voltage curves are thereby obtained experimentally for the K-series of chromium, copper, and silver, and for the L-series of lanthanum and lead. The results are in agreement with earlier observations of Webster [Abstract 1046 (1916)] and Wooton [Abstract 438 (1919)], using other substances and a lower range of voltage. At high voltages the intensity of the lines reaches a maximum, the limit being determined by absorption of the X-rays in the antikathode. The theoretical bearing of the results is discussed in conclusion. A. B. W.

550. *Continuous X-Ray Spectrum for Different Discharge Frequencies.* **A. Karolus.** (Ann. d. Physik, 72. 8. pp. 595–616, Nov., 1923.)—Using an X-ray tube excited by a.c. of 50 to 500 frequency, important departures from Lilienfeld's relation ($\lambda = 12 \cdot 3/V_{max.}$) for the limiting wave-length have been experimentally observed. A. B. W.

551. *The Spectrum of Scattered X-Rays.* **A. H. Compton.** (Phys. Rev. 22. pp. 409–413, Nov., 1923.)—The spectrum of molybdenum K_a rays scattered by graphite at 45°, 90°, and 135° has been compared with the spectrum of the primary beam. A primary spectrum line when scattered is broken up into two lines, an "unmodified" line whose wave-length remains unchanged, and a "modified" line whose wave-length is greater than that of the primary spectrum line. Within a probable error of about 0·001 Å., the difference in the wave-lengths $(\lambda - \lambda_0)$ increases with the angle θ between the primary and the scattered rays according to the quantum relation $(\lambda - \lambda_0) = \lambda(1 - \cos\theta)$, where $\lambda = h/mc = 0 \cdot 0242$ Å. This wave-lengths change is confirmed also by absorption measurements. The modified ray does not seem to be as homogeneous as the unmodified ray; it is less intense at small angles and more intense at large angles than is the unmodified ray. An X-ray tube of small diameter and with a water-cooled target is described, which is suitable for giving intense X-rays. **Author.**

RADIO-ACTIVITY.

552. *Radio-Activity of Mineral Springs.* **C. Viola.** (Accad. Lincei, Atti, 32. ii. pp. 7–11, July, 1923.)—An investigation of the mineral waters of S. Andrea di Medesano. The radio-activity runs from 3·38 to 11·2 Mache units in the different springs. A. D.

553. *The Relative Activities of Radio-Active Substances in an Unchanged Primary Uranium Mineral.* **W. P. Widdowson** and **A. S. Russell.** (Phil. Mag. 46. pp. 915–929, Nov., 1923.)—Boltwood found that in such a mineral about 2·2 atoms of uranium break up for one of each of its disintegration products, and that the total activity due to the actinium series is about 28 per cent. of that of uranium taken as unity. Hahn and Meitner found 3 per cent. for the last-named quantity, and Meyer 4·2 per cent., while Rutherford suggested that 8 per cent. of the parent substance was transformed into the actinium series. The authors describe the methods employed by them in a careful repetition of part of Boltwood's work, using the improved chemical methods which have been developed since 1906; the results agree with those of Boltwood on the lowness of the relative activity of the uranium mineral as compared with that of the uranium it contains, but disagree on the relative activities of polonium, ionium, radium, and uranium; for these the values found are close to the theoretical values. The ratio of the activity of the actinium series to that of the radium series is 0·029, in agreement with Hahn. It is concluded that measurements along the lines employed cannot decide whether the actinium series arises as a branch of the uranium series, or comes independently from an isotope of uranium. The ratio of uranium to one of its disintegration products, corrected for the relative ionisation of these bodies is found to be 2·04, as compared with Boltwood's number 2·2. H. N. A.

554. *A Method of Measuring a Large Radiation from a Radio-Active Substance.* **(Miss) S. Maracineanu.** (Comptes Rendus, 177. pp. 682–685, Oct. 15, 1923.)—For small voltages the curve of saturation is a straight line, and Ohm's law holds; with uniform ionisation $i = sehn_0(k_1 + k_2)$, where i is the ionisation current, e the charge of an ion, n_0 the concentration of the ions, h the field intensity, k_1 and k_2 the mobilities of the positive and negative ions, s the effective surface of the upper plate of the ionisation chamber. The saturation current is $I = sNde$, where N is the number of positive and negative ions produced, in unit time, in unit volume of the gas, and d is the distance between the plates. Now $n = \sqrt{N/a}$, where a is the coefficient of recombination, and it follows that i is proportional to $\sqrt{I}$, or $\sqrt{I}/i = K$, so that it is possible by measuring i to find the value of I. Measurements were made which showed that $\sqrt{I}/i$ was nearly constant from $I = 0{\cdot}04656$ up to 142·9 (arbitrary units) for certain conditions of distance; and the author concludes that, in cases where I is too large to be measured directly, its value can be obtained, with considerable accuracy, by measuring i. H. N. A.

555. *Diffusion of Radio-Active Elements in Metals.* **L. Wertenstein** and **(Miss) H. Dobrowolska.** (J. de Physique et le Radium, 4. pp. 324–

332, Sept., 1923.)—Employing a method applicable to the diffusion of radio-active elements in metal layers and based on the observation of scintillations, the authors have studied the diffusion of RaB + C and of Po in the elements gold, silver, and platinum at ordinary temperatures. The principle of the method is as follows: A thin layer of the metal is coated on one side only with the radio-active substance. If the substance emits α-rays it is desirable to choose the thickness of the metal layer just sufficient to absorb the rays completely. In these conditions a zinc sulphide screen is placed in contact with the inactive side of the metal sheet. At first the screen shows no scintillations (or only a few due to long-range α-particles—see Rutherford's papers). As the diffusion of the radio-active material into the metal progresses scintillations appear on the ZnS screen and their number steadily increases. By observing the rate of increase with time and thickness of layer the diffusion constant can be determined accurately.

Employing this ingenious method, the following results have been obtained:

Metal.	Screen Diffusion Coefficient $\times 10^7$ cm.²/day.
Silver	3·77
Gold	8·2
Platinum	3·41

The coefficients of diffusion in all the metals studied are of the same order of magnitude. They do not follow the order of fusibilities but rather the inverse order of hardness of the metals studied. It is remarkable that the coefficient of diffusion of Po in gold is approximately only 1/1000 of the coefficient of diffusion of RaC in the same metal. It is suggested in explanation that gold and Po form a chemical compound, hence the diffusion is abnormally slow. A. B. W.

556. *The Short-Lived Radio-Active Products of Uranium.* **W. G. Guy** and **A. S. Russell.** (Chem. Soc., J. 123. pp. 2618–2631, Oct., 1923.)—Hahn has recently found that a new radio-active product, uranium Z, is always present in very small amount (about 0·2 per cent.) in a solution of UX, and is an isotope of proto-actinium, half-value period 6·7 hours. The authors describe the method used by them in separating this substance. A solution of tantalum was added to the UX solution, which was then boiled, and substances of atomic number 91, including UZ, were precipitated; three determinations of the half-value period gave 6·70, 6·69, and 6·69 hours in agreement with Hahn. Assuming with Hahn that UX_1 breaks up, partly into UX_2 and partly into UZ, the branching ratio has been measured, and the value 0·9967 to 0·0033 obtained. Hahn found 0·9965 to 0·0035. The absolute value of this ratio cannot be known, however, until the relative ionisations of equal numbers of β-particles from UX_2 and UZ are known; there is no simple way of arriving at this at present. The half-value period of UX_2 was found to be 70·5 seconds, or 1·175 minutes, in good agreement with Hahn's and Meitner's 1·17 minutes and a little higher than Fajans' and

Göhring's 1·15 minutes. Hahn and Meitner found for UY the half-value period 25·5 hours; the authors find 27·8 hours. The equilibrium ratio of UY to UX, in preparations of uranium, has been measured as 1·031. This is higher than, but of the same order as, Hahn's value, and is very close to the values obtained for the equilibrium ratio of proto-actinium to ionium (0·03), which may be expected to be the same. Hahn's scheme for representing the position of UZ in the disintegration series is regarded as most probable. A suggestion is made connecting periods of substances and their equilibrium ratio. H. N. A.

557. *Colouring of the Diamond by Radium Radiation.* **S. C. Lind** and **D. C. Bardwell.** (Frank. Inst., J. 196. pp. 521–528, Oct., 1923.)—The results of various investigators attempting to colour the diamond by radium radiation have not been entirely uniform and in the main were unsuccessful. Doelter classes diamonds as the most difficult of all minerals to colour, and reports for the most part failures or very slight colouring. On the other hand, Crookes obtained in a few cases bluish-green and sage-green colours, and A. Miethe produced a yellow colour from a colourless diamond in one instance. As reported in a preceding paper [see Abstract 2217 (1923)], the author has found that all minerals except diamond, that can be coloured by radium radiation, are coloured by the penetrating (beta and gamma) rays transmitted through the glass tube containing the radium salt. As the result of the present experiments, it is found that the diamond is not coloured by the penetrating radiation from radium salt in glass tubes 0·5 to 1 mm. thick. Diamond is always coloured green by direct radiation, either from high-grade radium salt or from the gas—radium emanation. No exceptions are met in more than 30 specimens. The green colour is apparently light-permanent, but can be removed by heating to a dull red. Yellow and brown diamonds are also coloured green, but are restored, by heating, to their original colours. In the case of large deep brown stones the colour masking by green is not complete. Recutting the crystal after colouring removes the green colour. This is possibly a heat effect during cutting and does not prove that the colour is merely a surface effect. The depth of penetration of the colour zone could not be determined. If it is an alpha-ray effect, it would be limited by a range of alpha-rays in diamond, about 0·001 inch. But reflection of green light from the highly polished surface interferes with optical observations. Radiation by emanation is more effective than by salts, owing to the greater absorption of α-rays by the salt itself. In some cases in emanation, but never in salt, the radiation resulted in the production of "carbon spots" in the interior of the crystal. The black spots are probably a form of carbon, the nature of which was not definitely determined. They can be removed by prolonged heating in a blast flame. The "carbon spots" are undoubtedly beyond the range of α-rays in the crystals, which suggests that the colour may be penetrating also and that both are produced by some form of secondary radiation more penetrating than α-rays. A. E. G.

558. *Investigation of the Alteration of Colour of Crystals by Radium Rays, using Ostwald's Method of Colour Measurement.* **P. Ludewig** and **F. Reuther.** (Zeits. f. Physik, 18. 3–4. pp. 183–198, 1923.)—A special lead container was employed with a place for the radium preparation at the centre, and holders for the crystal plates placed regularly round it, so that all receive equal radiation; the container was designed so that it could be placed in a safe, in which other radium preparations were kept, and the lead was thick enought to prevent these from affecting the crystals; the thickness of the crystals was confined to 2 mm., so that the field of radiation should be sufficiently homogeneous in each crystal. The radiation could, when necessary, be passed through a brass filter, 1·5 mm. thick, before falling on the crystals. In Ostwald's method of colour measurement the colour tint and the amounts of white and of black mixed with it are separately measured; in other words, the effects of selective and of general absorption are determined. The Ostwald chrometer did not prove sufficiently accurate in measuring the amounts of white and of black, and a half-shadow photometer was added to it for this purpose. It was found that sylvine, which was rapidly coloured by the radium rays, lost its colour so rapidly in daylight that no measurements could be taken. Rock salt on the contrary holds its colour well, and remains unaltered in the dark for several months. The tint was No. 7 to No. 8 in Ostwald's scale; the amount of white diminished on exposure, very fast at first, and afterwards slower; but did not reach a limiting value in 56 days; the amount of black remained nearly constant, the amount of the full tint consequently increased, quickly at first and afterwards more slowly, without reaching a limiting value. The crystals coloured with β- and γ-rays, and those coloured only with hard γ-rays, showed qualitatively the same relations, though when the β- and soft γ-rays were filtered out, the coloration proceeded at a lower rate. H. N. A.

559. *Determination by a Chemical Method of the Mean Effective Path of Alpha Particles in Small Spheres.* **S. C. Lind** and **D. C. Bardwell.** (Am. Chem. Soc., J. 45. pp. 2585–2592, Nov., 1923.)—In studying the relation between ionisation and chemical reaction, in gases containing radium emanation (radon), the ionisation cannot be measured, but must be calculated from the quantity of radon and the mean path of the α-particles in the gas being acted upon. If spherical reaction vessels are used, the mean path of all the α-particles from radon atoms is $0{\cdot}75r$, where r is the radius of the sphere, if this is small enough to allow all the α-particles given off by the radon atoms to reach the glass walls. The mean path from points on the inner surface, where RaA and RaC are sending out α-particles, is $0{\cdot}5r$; but there is doubt as to the amount of these substances, and a method is suggested for settling this, in which the radon, instead of being mixed with the gas, is contained in a minute bulb at the centre of the larger bulb, so that all the α-particles travel a distance r before they reach the walls. O and H were placed in the large bulb, and the change in pressure due to chemical union between them owing to the ionisation caused by the α-particles was measured, and this was compared with the result obtained when the radon was mixed with the gas by breaking the small bulb. After a number of corrections were taken into account, it was found that the mean effective path of the α-particles (in mixtures) is $0{\cdot}61 \pm 0{\cdot}01 \times$ the radius of the bulb. H. N. A.

560. *Characteristics of the Alpha-Ray Bulb as a Source of Ionisation.* **D. C. Bardwell** and **H. A. Doerner.** (Am. Chem. Soc., J. 45. pp. 2593–2599, Nov., 1923.)—Deals with the corrections used in the paper by Lind and Bardwell [see preceding abstract]. The small bulb at the centre of the larger one, in which the radon was at first confined, has a capillary connection at one end and a small tip of thickened glass at the other. Both of these intercept α-rays, and this loss must be allowed for; the radius of the α-ray bulb must also be taken into account, also the obliquity of passage of the rays through the glass wall, and the change of ionisation along the path, as expressed by the Geiger curve. A dead arm, containing gas which is not radiated, is necessary in mounting the α-ray bulbs, and the effect of this must be considered, and the change of ionisation intensity with pressure. When the radon is mixed with the gases which are being acted on ionisation is produced by the recoil atoms. This is not the case when the radon is confined to the α-ray bulb, and this difference in the conditions of the two experiments must be taken into account. H. N. A.

561. *The Effect of Deviations from the Inverse Square Law on the Scattering of α-Particles.* **E. S. Bieler.** (Cambridge Phil. Soc., Proc. 21. pp. 686–700, Nov., 1923.)—To explain the occasional large angle deflections, when a beam of α-particles passes through a thin film of matter, Rutherford proposed the nuclear theory of the atom in 1911, and showed thereby that almost the whole of the scattering is due to the inverse square law electrostatic field of the heavy central nucleus, and that the scattering due to the electrons may be neglected. Confirmatory experimental work was carried out by Geiger and Marsden, and by Chadwick [see Abstract 366 (1921)]. Experimental work by the present author, to be published shortly, indicates that when the distance of closest approach of the α-particle to the deflecting nucleus becomes very short the scattering is less than would be expected on the inverse square law. This decrease finds an explanation on the assumption that, in addition to the inverse square law repulsive force between the nucleus and the α-particle, there is an attractive force varying inversely as a higher power of the distance than the second. The calculations for such combined laws of force are now placed on record and are dealt with under the headings: The Scattering under any Law of Force; The Orbit of the α-Particle in the Combined Field of Force; The Inverse Cube Law; The Inverse Fourth Power Law; The Correction for the Motion of the Nucleus; The Apsidal Distance. The paper is entirely mathematical, and the author hopes that these laborious calculations will prove of use to other workers in this field. H. H. Ho.

562. *A Relation between the Energies of α-Rays and the Atomic Numbers of the Elements.* **L. Myssowsky.** (Zeits. f. Physik, 18. 5. pp. 304–306, 1923.)—Ellis showed that a relation of the form $E = h\nu - \omega$ exists between the energy of secondary β-rays emitted under the action of γ-rays, for light elements. Also the curves representing the energy of secondary β-rays for W, Pt, Pb, and U under γ-rays of RaB against atomic numbers consisted of three straight lines. The author shows that a similar relationship exists between the atomic numbers of radio-active elements and the energies of their α-rays using the velocities given by Geiger. The mean difference between the α-rays from isotopes is constant, but RaC, ThC, AcC, and U II do not lie on the straight lines. Th is not accurately placed. Little resemblance to the β-ray curves of Ellis is to be expected for reasons connected with the conditions of emission, but there may be some connection with the Geiger-Nuttall rule. W. V. M.

HEAT.

563. *Measurement of Very High Temperature.* **I. O. Griffith.** (Nature, 112. p. 589, Oct. 20, 1923.)—Lummer's results (1914) for the temperature of an arc burning in a gas at high pressure are stated to be unsatisfactory, the figures being nearly 3000° too low. The experiments are repeated and extended, with modifications of method. The ratio of the intensities of the emitted light at two wave-lengths as far as possible apart is determined. The intensity is measured both by Merton's wedge method, and by making use of the photoelectric effect. A temperature of 8620° is recorded for the arc in nitrogen at 80 atmospheres pressure. A. B. C. L.

564. *Temperature Measurement with the Einthoven Galvanometer.* **F. Adcock** and **E. H. Wells.** (Inst. El. Eng., J. 61. pp. 1115–1120, Oct., 1923.)—The object of the work here discussed is the investigation of the relationship between the temperature of the gas forming the charge of the gas engine and the thermometric record obtained. Attention is devoted particularly to the platinum resistance thermometer used in an unbalanced bridge with the Einthoven galvanometer. The force on the fibre of the galvanometer is considered and various types of fibre are compared in regard to their suitability. W. R. C.

565. *A New Recording Kata-Thermometer.* **E. H. J. Schuster.** (Journ. Sci. Instruments, 1. p. 30, Oct., 1923.)—The thermometer has its bulb uppermost, filled with toluene, and its stem bent to the form of a **U**, filled with mercury. The bulb contains a small heating coil; in the stem three wires are fused, one at 100°, one at 95°, and one lower down. Electric current is passed through the heating coil, but when the mercury reaches the wire at 100°, the current is diverted to pass into the circuits in the recording mechanism, and the bulb is cooled by the surrounding air. When the mercury drops to 95°, the current is once more diverted to the heating coil, and so on. The recording mechanism is, effectively, an electric clock with a magnetic clutch. By means of the apparatus, the time to cool for various external conditions can be obtained, and hence the rate of loss of heat in calories per sq. cm. per sec. calculated. W. G. B.

566. *Thermal Conductivities.* **W. B. Brown.** (Phys. Rev. 22. pp. 171–179, Aug., 1923.)—Thermal conductivities of some metals and eutectic alloys above and below their melting-points, 50° C. to 400° C. Drop of conductivity at the melting-point. Polymorphic change in thallium at 120° C. Eutectic alloys in fused state at 300° C. with temperature coefficients close to those for gases at the same temperature. A. D.

567. *Recording Drum.* **C. V. Boys.** (Journ. Sci. Instruments, 1. pp. 26–28, Oct., 1923.)—Description of gearing as used in Boys's integrating and recording gas calorimeter, made by Griffin; one revolution a month. Arrangement of pen is given. A. D.

568. *Theory of Specific Heats.* **E. Császár.** (Zeits. f. Physik, **19.** **3.** pp. 213–220, 1923.)—In this paper it is shown mathematically that in the theory of specific heats and black radiation it suffices to assume the presence of a discontinuity in the action of the atoms, some deviation from the classical laws, in the vicinity of the absolute zero. Thus, only those atoms behave with discontinuity, which are in the state to which the aggregate of the atoms are reduced when the whole body is brought near to the absolute zero, the other atoms follow the laws of classical physics. As to the nature of the discontinuity, various hypotheses are possible [see Abstract 446 (1913)]. E. H. B.

569. *The Specific Heats of Air for the Ranges of Temperature* 0° *to* 200° *and* − 80° *to* 250°. **M. Jakob.** (Zeits. techn. Physik, **4.** **12.** pp. 460–468, 1923. From the Reichsanstalt.)—The equation of the isothermals of air for the temperature range 0° to 200° C. and for pressures between 0 and 75 metres of mercury, deduced from the results obtained by Holborn and his co-workers [see Abstracts 92 (1916), 481 (1921), and 2304 (1922)], are employed to calculate the respective values of the specific heat of air at constant pressure (C_p), and of $C_p - C_v$ for the temperature range − 80° to 250°, the thermodynamic equations $C_p = \phi(T) - T\int(\partial^2 v/\partial T^2)\partial p/J$, and $C_p = C_v = - T(\partial v/\partial T)^2/J\,\partial v/\partial p$ being used in the calculations. The results are compared with values deduced in other ways by various physicists, and the comparison used to deduce the most probable values of C_p and C_v for air between − 80° and 250° C., at pressures ranging from 0 to 200 + 10^4 kgm. per sq. metre. Values of C_p, C_v, $C_p - C_v$ and of C_p/C_v so calculated are tabulated for temperature intervals of 50° C. and for pressure intervals of 50 × 10^4 kgm. per sq. metre throughout the respective ranges. Calculated results are as follows:

$10^{-4}p$ [kg . m^{-2}].	t	−79·3°.	−50°.	0°.	50°.	100°.	200°.	250°.
0	C_p ..	0·241	0·241	0·241	0·241	0·242	0·244	0·245
50		0·317	0·283	0·265	$0{\cdot}257_5$	0·253	$0{\cdot}249_5$	$0{\cdot}249_5$
100		0·416	$0{\cdot}326_5$	0·287	0·272	$0{\cdot}263_5$	$0{\cdot}255_5$	0·254
150		0·496	0·360	0·305	$0{\cdot}284_5$	$0{\cdot}272_5$	$0{\cdot}260_5$	0·258
200		0·515	0·380	0·320	$0{\cdot}295_5$	$0{\cdot}280_5$	0·265	0·262
0	C_v ..	0·172	0·172	0·172	$0{\cdot}172_5$	$0{\cdot}173_5$	$0{\cdot}175_5$	0·176
50		0·185	0·178	$0{\cdot}175_5$	0·176	0·176	$0{\cdot}176_5$	$0{\cdot}177_5$
100		0·196	$0{\cdot}182_5$	0·178	0·178	$0{\cdot}177_5$	0·178	0·179
150		0·206	0·186	$0{\cdot}179_5$	$0{\cdot}179_5$	0·179	$0{\cdot}179_5$	0·180
200		0·215	$0{\cdot}188_5$	0·181	0·181	0·181	0·181	0·181

Above − 50° C. the values given are considered to be correct probably to within 1 or 2 %; at − 80° C. the error is possibly of the order of 3 to 4 %. J. S. G. T.

570. *The Influence of Initial Pressure and Temperature of Previous Cooling in the Liquefaction of Hydrogen.* **W. Meissner.** (Zeits. f. Physik, **18.** **1.** pp. 12–25, 1923. From the Reichsanstalt.)—In the liquefaction of hydrogen by the Linde-Hampson method, liquid air is used for the initial cooling and the pressure before expansion ranges from 120 to 220 atmospheres. Opinions differ as to the conditions which give the best yield of liquid H, and for this reason the author discusses them theoretically. When expansion takes place the pressure falls to approximately one atmosphere. Taking $1/n$, *i.e.* the fraction of the gas passing through the nozzle which is liquefied, as the best practical measure of the efficiency of the machine, and denoting by the index 1 the gas before expansion and by index 0 after expansion, we have $q = i_1 - (1 - 1/n)i_0$ if q denotes the energy remaining in the apparatus, and $i = u + pv$, where $u =$ energy and $v =$ volume per gram. If the subscript f refers to liquid state and 2′ to gas state after expansion and $r_2 =$ latent heat of evaporation for state 2′, then $q = if/n = (i_2 - r_2)/n$. Hence we have $1/v = -(i_1 - i_0)/(r_2 + i_0 - i_2') = -\Delta i_T/(r_2 + i_0 - i_2') \ldots (1)$. Here Δi_T may be called the isothermal nozzle effect at a temperature T. Hence, since the denominator of this expression does not depend on the initial pressure, the value of $1/n$ is a maximum when Δi_T is a minimum, the initial temperature being constant. Applying the laws of thermodynamics it is shown that $1/n$ is a maximum for such values of p as make $\partial/\partial T(v/T)_{p_1} = 0$, or $(\partial v/\partial T)_{p_1} = v/T \ldots (2)$, which is the condition for the inversion curve of the Joule-Thomson effect. Hence $1/n$ is a maximum for pairs of values of p and T which lie on this curve. The values thus obtained for $1/n$ are relative maxima which hold for constant initial temperature T. The question now arises whether we can have an absolute maximum of $1/n$. For this to be the case, besides having $(\partial \Delta i_T/\partial p)_T = 0$ we must also have $(\partial \Delta i_T/\partial T)_p = 0$, and these two curves must have a common point. The values of p and T for this point would give an absolute minimum for Δi_T. The condition for this second curve, for which $(\partial \Delta i_T/\partial T)_p = 0$ is found to be $(\partial^2/\partial T^2)_p \int_{p_0}^{p_1} v\,dp_T = 0$. An absolute minimum of Δi_T is not, however, identical with an absolute maximum of $1/n$, since the denominator of (1), although independent of p_1, is not independent of T, since i_0 depends on T. Hence the curve $(\partial \Delta i_T/\partial T)_p = 0$ is not identical with the curve $\left(\partial \frac{1}{n} \Big/ \partial T\right)_p = 0$. This last condition requires $(1/\partial T)(\partial \Delta i_T/\partial T)_p = (1/r_2 + i_0 - i_2')(\partial i_0/\partial T)_p = cp_0/(r_2 + i_0 - i_2') \ldots (4)$. The right-hand side of (4) is + *ve*, but Δi_T is − *ve* for all points of the inversion curve. Hence $(\partial \Delta i_T/\partial T)_p$ must be − *ve*, if (4) is satisfied for a point on the inversion curve. For the higher temperatures of the inversion curve it is known to be + *ve*. Therefore, condition (4) is certainly not satisfied when (3) does not cut the inversion curve. In order to investigate (3) the author introduces "corresponding" values of temperature, pressure, and volume, *i.e.* ratio to critical value, and expands his expressions in series: In the rest of the paper the author gives the necessary calculations with tables of values of constants involved. He plots the curves $(\partial \Delta i_T/\partial p)_T = 0$, and $(\partial \Delta i_T/\partial T)_p = 0$, and shows that they have no common point and therefore there is no absolute maximum of $1/n$. Finally, he calculates $1/n$ from (1) and finds that for $T_0 = 80$, $p_i = 165$ atmos., $1/n = 0{\cdot}177$. For $T_0 = 66{\cdot}4$, $p_i = 161$ atmos., and $1/n + 0{\cdot}266$. The value obtained in practice is generally lower and hence there is probably room for improvement in carrying out the process. T. B.

571. *The Absorption Capacity of Blackened Surfaces at Ordinary Temperatures.* **G. Michel** and **A. Kussmann.** (Zeits. f. Physik, 18. 5.

pp. 263–271, 1923.)—The two methods hitherto in use for the measurement of absorption capacity are first described, *viz.* the reflection method of Ångström and that based on emission as used by Crova and Compan, Kurlbaum, and Rubens and Hoffmann [see Abstract 1178 (1923)]. Differences between the results afforded are first discussed, following which comes the very full description of a new modification of the emission method which renders possible the measurement of absorption capacity at ordinary temperatures. The materials investigated were Crova's soot and the mixture of soda, water glass, and soot described by Rubens and Hoffmann. The temperature dependence of the true emission capacity assumed by Rubens and Hoffmann and established by Hoffmann for the temperature interval 184–100° C. has been confirmed by the present measurements. H. H. Ho.

572. *Vapour Pressure and Density of Sodium Chloride Solutions.* **W. R. Bousfield** and **C. Elspeth Bousfield.** (Roy. Soc., Proc. 103. pp. 429–463, June 1, 1923.)—A series of accurate determinations of the vapour pressure of aqueous NaCl solutions at 18° C. to serve as a scale of reference for other determinations. The direct method of measurement was chosen. The chief difficulty to be overcome was the presence of air, either dissolved in the solutions and in the water, or adhering to the walls of the apparatus. The apparatus was designed so as to exclude air.

The apparatus consisted of a **U** tube mounted on a barometer tube. The two limbs of the **U** tube could be hermetically sealed. One limb contained air-freed water and the other the solution under test. From the observations a standard table for the vapour pressure at 18° C. over the whole range of concentrations was deduced. A new table of densities of aqueous NaCl solutions correct to within ±2 in the fifth place of decimals is given. A simple method of obtaining approximate molecular weights is described. E. G.

573. *The Integration of the Equation of Heat Conduction.* **I. Runge.** (Zeits. f. Physik, 18. 3–4. pp. 228–231, 1923.)—The equation of heat conduction: $\frac{d}{dx}\{\lambda(\mathrm{T})q\frac{dt}{dx}\} = -i^2\omega(\mathrm{T})/q + 2\sqrt{\pi q}s(\mathrm{T})$ is integrated by the substitution $u = \lambda(\mathrm{T})dt/dx$. M. H. A. N.

574. *The Quantum Theory of Vapour Pressure and of Dissociation.* **D. Enskog.** (Ann. d. Physik, 72. 5. pp. 321–344, Sept. 28, 1923.)—This is a mathematical paper in which the author, making use of Boltzmann's relation between entropy and probability and the Maxwell-Gibbs relation between entropy and phase volume, deduces expressions for vapour pressure and dissociation in terms of the quantum theory. An expression for the entropy of polyatomic gases is also obtained. The paper is not suitable for a brief abstract. T. B.

575. *The Thermal Ionisation of Gases and the Fundamental Elementary Processes Involved.* **R. Becker.** (Zeits. f. Physik, 18. 6. pp. 325–343, 1923.)—A fundamental viewpoint of the mechanism of thermal ionisation is better obtained from a study of monatomic and mono-valent gases than from any other chemical reaction, and constitutes the subject matter of the present paper [see also Abstract 913 (1923)]. Section 1 deals with the equilibrium formula according to quantum statistics. Section 2 considers the statistical weights of the various stationary states. Section 3 investigates the emission and absorption mechanism of radiation processes. Section 4 then deals with the non-radiating emission and absorption of electrons. The paper is entirely mathematical. H. H. Ho.

576. *Quanta, the Kinetic Theory of Gases, and the Principle of Fermat.* **L. de Broglie.** (Comptes Rendus, 177. pp. 630–632, Oct. 8, 1923.)—Planck and Nernst have shown that the idea of quantum must be introduced in the kinetic theory of gases, in order to calculate the constants of entropy, and the chemical constants, which are of such great importance in thermodynamics. The author, considering each atom of velocity βc as linked to a group of waves of which the phase velocities are $V = c/\beta$, the frequencies $m_0 c^2/h\sqrt{1-\beta^2}$, and the group velocities $U = \beta c$, shows that the number of atoms of total energy w in the element of volume is: const . $(4\pi/h^3)m_0^{3/2} . \sqrt{2w} . dw . dx . dy . dz . e^{-w/kT}$, a result which justifies Planck's method, and leads to the usual form of the law of Maxwell. Further information is obtained by introducing Fermat's principle, which can be put in the form $\delta\int\frac{\nu ds}{V} = \delta\int(m_0\beta c/h\sqrt{1-\beta^2})ds = 0$. The fundamental bond which links the two great principles of geometrical optics and dynamics is thus plainly shown. Amongst the trajectories dynamically possible, certain have the property of being in resonance with the phase wave; these are the stable trajectories of the Bohr theory for which $\int \nu ds/V$ is a whole number. It is to be observed that the integral of Fermat introduces the product of a frequency by a time, and the action is only introduced in consequence of the proportionality of energy and frequency. This proportionality constitutes one of the aspects of the connection between space and time, a connection which is by no means intuitive, as our usual experience has taught us to dissociate these two notions. T. B.

577. *The Thermal Equilibrium between Radiation and Free Electrons.* **W. Pauli, Jr.** (Zeits. f. Physik, 18. 5. pp. 272–286, 1923.)—The thermal equilibrium between radiation and free electrons was investigated by Lorentz and Fokker on the basis of classical dynamics and afforded the result that not only the Planck spectral distribution of the radiation energy could not obtain in the presence of an electron in a radiation space, but that in addition the electron did not possess the amount of $3/2\ kT$ of average kinetic energy of translation demanded by the statistical heat theory. The important conclusion could therefore be drawn that the classical theory failed to account for the reciprocal effect of radiation and free electrons. The object of the present paper is therefore to derive a quantum mechanism for this reciprocal effect which will satisfy the thermodynamic demand that electrons with the Maxwell velocity distribution and a Planck radiation field must be in equilibrium. Einstein's general result for the reciprocal effect between radiation and material systems, *e.g.* atoms, is first discussed, and the deviations necessitated for the case of an equilibrium between radiation and free electrons pointed out. It is an essential assumption in Einstein's considerations that the forces between the particles (electrons, nuclei, etc.) of the material system are great compared with those of the external radiation field, but in this case the former disappear and the latter alone are present. This has the consequence that spontaneous transformations do not in general take place, and that only the translation energy of the electrons need be considered. The paper is mathematical throughout. H. H. Ho.

578. *The Employment of Selective Transparent Mirrors in the Radiation Theory.* **O. Halpern.** (Ann. d. Physik, 72. 7. pp. 516–518, Nov., 1923).—The author describes a selective transparent mirror as a plate which totally reflects radiation within definite frequency limits, but which transmits completely radiation of other frequencies. The problem as to whether the existence of such a mirror is compatible with the second law of thermodynamics has been the subject of discussion for a number of years. Wien's process for the complete transformation of heat into work by the aid of such a mirror has been critically examined by Reiche [see Abstract 824 (1908)], who declared it to be invalid and the second law therefore not violated. The present author now attempts to prove that the Wien hypothesis may be correct, although the proof submitted by Wien is fallacious. H. H. Ho.

579. *Physical Applications of Heaviside's Expansion Theorem.* **E. P. Adams.** (Am. Phil. Soc., Proc. 62. 2. pp. 26–47, 1923.)—The expansion theorem may be stated as follows: Let p represent the operator $\partial/\partial t$, and assume the solution of the differential equation satisfying the boundary conditions to be obtainable in the operational form $v = Y(p)v_0/Z(p)$, where v_0 is a constant, then the solution of the problem is $v = v_0\{Y(0)/Z(0) + \sum_{m=1}^{m=\infty} Y(p_m)e^{p_m t}/p_m Z'(p_m)\}$, where the p_m denote the real roots of $Z(p) = 0$ in ascending order of magnitude, and the summation is to be taken over all the real roots, except zero. This solution makes $v = 0$ at $t = 0$.

The problems of which solutions are obtained are the distribution of temperature in (1) a cone of circular section, carrying a steady electric current, at any time after the current begins to flow. The ends of the wire are kept at a temperature $v = 0$, and radiation is supposed to take place from the lateral surface of the wire into the medium, at temperature $v = 0$, so that the amount of energy radiated from unit surface in unit time is proportional to its temperature. The solution is obtained: (*a*) For no radial temperature gradient; (*b*) for no longitudinal temperature gradient; (*c*) for the general case. (2) A sphere exposed to radiation from one side, so that over half the surface of the sphere the radiation received on unit surface in unit time is $\epsilon \cos \theta$, the angle θ being measured from the axis of the hemisphere receiving the radiation. The whole surface of the sphere is supposed to radiate energy into the medium at the rate hv per unit area, v being the surface temperature. (3) A finite circular cylinder exposed to uniform radiation over one base. (4) A finite circular cylinder exposed to uniform radiation on one half of the curved surface. G. W. de T.

SOUND.

580. *Sensitivity of the Ear as Function of Pitch.* **F. W. Kranz.** (Phys. Rev. 22. pp. 66–72, July, 1923.)—Sensitivity-frequency curves are here determined by continuously ranging the pitch for different intensity levels. The threshold sensitivity curve for audition may be determined by varying the intensity at many different pitches, or by varying the pitch at many intensities, noting the ranges of pitch which are audible for each intensity. The latter method enables irregularities in the curve to be more easily and surely determined. In these experiments, a thermophone actuated by current from a vacuum tube oscillator was used, the pitch being controlled by means of a continuously varying inductance, and the threshold sensitivity curve for the frequency range of 360 to 3000 per sec. was determined by the use of successive levels of intensity having an intensity ratio of 2 : 1. Curves were thus obtained for *thirty normal ears. They show remarkable individual irregularities,* not only being different for different individuals, but often for the two ears of the same person. In several cases the sensitivity changes by a factor of 200 to 1000 with a change of pitch of a semi-tone. An acceptable theory of the mechanism of audition must explain such abrupt changes. The *average sensitivity* increases from $10^{-7\cdot 2}$ for 360 to an approximately constant value of $10^{-8\cdot 6}$ ergs. cm.$^{-2}$ sec.$^{-1}$ for frequencies above 1300 per sec. E. H. B.

581. *Effect of Conical Horns on Intensity of Sound from Organ Pipe.* **J. H. Cloud.** (Phys. Rev. 22. pp. 73–77, July, 1923.)—In a room lined with hair felt one inch thick, to reduce resonance effects, readings taken with a Webster phonometer showed that while the horn (50 cm. long, 6° flare) doubled the intensity, it acted merely as a resonator and did not concentrate the energy in front to any measurable extent. Outdoor experiments gave the same result except that the intensity was increased by only one half. The Webster phonometer with a disc supported by wires under tension is a convenient portable instrument, as sensitive as the ear to the pitch to which it is tuned, but it shows a very sharp resonance to its natural frequency, and this selectivity limits its usefulness. The Rayleigh disc phonometer is also described, and it is pointed out that it may be used for absolute measures of the energy density of sound. E. H. B.

582. *Vibration of Air in Quill Tubes: Single Telephonic Exciter.* **C. Barus.** (Nat. Acad. Sci., Proc. 9. pp. 376–378, Nov., 1923.)—A paper following up the work of previous ones [see Abstract 2228 (1923)]. The preceding methods with two co-operating telephones introduce certain complications. In the case of straight longitudinal tubes the paired pinholes must be displaced to follow the modes of the overtones. In transverse quill tubes the pin-holes are fixed, but their tube length is a material addition to the remaining tube length. In this respect a new method with a **U** tube operated by a single telephone has advantages, and this is the plan here dealt with. The details of the various overtones obtained are shown in a series of graphs. E. H. B.

583. *Acoustical Properties of Gels. Part I. Velocity of Sound in Rods of Silica Gel.* **M. Prasad.** (Koll. Zeits. 33. pp. 279–284, Nov., 1923.)—It has been ascertained in former work that by cautiously tapping a vessel containing silicic acid gel, a sound is emitted. Measurements of the period of vibration have formerly usually been made on gels contained in glass tubes. The presence of the tubes influences the quality and period of the tones on account of the two vibrating together. In the present work, gels are prepared by mixing together sodium silicate with a 10 % solution of ammonium acetate as employed by S. S. Bhatnagar and K. K. Mathur. After completely settling, the gel was subjected on a filter to a pressure of 70·55 dynes to 130·4 dynes per sq. cm. for 24 hrs. In this time most of the liquid had disappeared and there remained a material of definite solidity. The liquid passed through was estimated by measuring at regular intervals the loss in weight of the gel. Measurements on elasticity of the stick of gel were made by clamping one end of the stick firmly while the other end was free. A small piece of paper with a line drawn on it was fastened on the free end, to which was also attached a small aluminium pan suspended by a light strip to hold weights. The deflections were measured by a cathetometer reading to 0·0005 cm. The length and thickness of the gel stick were measured by calipers. The elasticity is then calculated from the formula, $E = \frac{4mgl^3}{3a^4d}$, where E = Young's modulus for the gel stick; m = load; g = gravitational constant; l = length and a the radius of the gel stick; and d = deflection.

The values of M/d were taken within a range in which Hooke's law is obeyed.

The variation of elasticity with the quantity of liquid relatively to solid phase was investigated. The elasticity showed a large increase with increasing dehydration.

The velocity of sound was then calculated from the elasticity by means of Newton's formula $V = \sqrt{(E/D)}$, where V = velocity of sound in the gel, E = elasticity and D the density of the gel. Determinations of density were made by immersion in kerosene.

A second method was then applied for evaluating the velocity by making use of the formula of Wertheim: $V = n\lambda$, where n = the periodicity and λ the wave-length. A determination of the pitch of the vibrating rod was made by suspending the rod, by a clamp holding it in the middle, over an air column in a glass tube of such a length as to resonate with the gel stick when the rod was tapped at the end near the aperture of the resonating tube. In this case the following relation applies: $\lambda = 2l$. The pitch of the stick is given by the expression $33{,}100 + 61t = 4n(L + 0\cdot6r)$, where 33,100 represents the velocity of sound in air at the temperature 0° C., t is the temperature, L the length of the air column in resonance with the gel stick, and r the radius of the air column. In the case of gels of different liquid content, the values of the velocities calculated by this method are compared with those derived from the elasticity measurements and a close agreement is obtained between the two sets of values. The results are in accordance with the view that the gel is a colloidal system in which the liquid is the disperse phase and the solid, *i.e.* silicic acid, the dispersion medium.

J. N. P.

ELECTRICITY AND MAGNETISM.

THEORY, ELECTROSTATICS, AND ATMOSPHERIC ELECTRICITY.

584. *Electromagnetic Field of an Electron in Movement.* **F. J. de Wisniewski.** (Arch. des Sciences, 5. pp. 370–379, Sept.–Oct., 1923.)—The use of retarded potentials leads to solutions of the equations of the electromagnetic field which are not in harmony with the stability of systems made up of electrons in movement. The author has worked out the problem *de novo*, without retarded potentials, and has arrived directly at the Einstein relations. A. D.

585. *The Fitzgerald-Lorentz Contraction and Paschsky's Theorem.* **N. v. Raschevsky.** (Zeits. f. Physik, 18. 2. pp. 120–130, 1923.)—The author in this paper first establishes electromagnetic field equations in accordance with Paschsky's Theorem [see Abstract 1280 (1922)]. He then proves that these equations when applied to a rigid spherical electron give Lorentz's formulæ for its electromagnetic mass. G. W. DE T.

586. *Intrinsic Magnetic Fields.* **L. Page.** (Phys. Rev. 22. pp. 188–192, Aug., 1923.)—Emission theory of electromagnetic fields [see Abstract 1797 (1914)]. The intrinsic magnetic field is defined as that portion of the field which cannot be annihilated by the Lorentz transformation. It can be represented by lines of force carried by the same moving elements as carry the electric field; a potential is given for it. A relation between the frequency of emission of moving elements and the number of lines of force to a tube is deduced on the assumption that the latter number is the same for the electric and magnetic fields and that each moving element marks the intersection of an electric and a magnetic line of force. A. D.

587. *A Method for the Investigation of Electrical Alternating Fields.* **N. Semenoff** and **A. Walther.** (Zeits. f. Physik, 19. 2. pp. 136–140, 1923.)—In this paper a method is described for obtaining potential measurements in changing electric fields, which will be serviceable for technical application. It is claimed to be the first of its kind. Experimental details are given very fully with discussion of the various difficulties which arise. The method is stated to afford measurements in the stationary glow light of alternating fields of high potential. H. H. Ho.

588. *Lines of Electric Force.* **G. L. Addenbrooke** on behalf of **E. E. Brooks.** (Inst. El. Eng., J. 61. pp. 1141–1143, Oct., 1923.)—Gives illustrations of a method of showing the electric lines of force between two conductors, based upon the well-known method with iron filings. A dielectric medium, such as turpentine, is used in this case in which bodies, such as granular aniline dyes, are suspended in fine division and which set along the lines of force when the two electrodes are electrified by a Wimshurst machine. The usual lecture examples are illustrated, including the fringe effects at the edges of a parallel condenser. B. J. L.

589. *The Contact Electricity of Solid Dielectrics.* **H. F. Richards.** (Phys. Rev. 22. pp. 122–133, Aug., 1923.)—The electric charges produced by wringing optically flat surfaces together were measured in order to determine whether or not there is a possibility of formulating a single contact theory which will include metals and dielectrics. A

Experiments with flint glass and steel proved that the frictional charge is independent of the amount of friction provided only that intimate contact be established, and is proportional to the area of contact. The charge was not affected by the ionisation of the residual air molecules between the surfaces by X-rays and was also found to be independent of the duration of contact. The failure of the double layer to recombine under these conditions proves that it was sustained by a voltaic field. The charge per square centimetre Q_{12} of a material 1 in contact with material 2 was found for eight different pairs of the materials quartz, fluorite, crown glass, flint glass, and steel to satisfy approximately the equation $Q_{12} = C(K_1 - K_2)$ where K_1 and K_2 are the dielectric constants and C a positive quantity equal to 4·43 e.s.u., a mathematical expression of Coehn's law [Abstract 505 (1898) and 1322 (1914)].

The electric effect of compressing amorphous dielectrics was found by pressing together two kinds of sheet rubber; the charge on the compressible dielectric was found to be independent of the nature of the material against which it was pressed, proving that it is not a voltaic effect, and that amorphous as well as crystalline substances can be electrified by pressure. The electric effect of collision of a solid insulator and a metal was found to be consistently opposite in sign to the frictional effect, suggesting that collision must be considered as producing two effects, one a voltaic charge and the other a transfer of electrons from the metal to the dielectric. The dielectric constant of steel as suggested by these results is 3·1 and not infinity, a value consistent with other considerations which seem to show that the dielectric constant of metals is not infinitely great, but of the order of 4·0. W. V. M.

590. *Registration of the Electrical Conductivity of the Air in a Cellar.* **W. Schlenck.** (Akad. Wiss. Wien, Ber. 131. 2a. No. 6–7. pp. 437–443, 1922.)—The object of the present series of experiments, which are a continuation of similar measurements by Schweidler and Sperlich, is to establish whether in a completely closed cellar there takes place a daily change in the electrical condition of the atmosphere, and also whether there exists any connection between it and the various meteorological factors. The electrical conductivity of the cellar air was measured by means of a mechanically registering Benndorf electrometer, and a similar daily period was found to that in the open air. Investigations into the content of absorption nuclei in the air gave the result that for the explanation of the conductivity, the decisive factor is the enrichment or deprivation of dust nuclei. This procedure runs analogously with that in the free atmosphere, so that also within a closed space the abnormal decrease or increase of dust nuclei by south wind and west weather on the one hand, and by strong mist on the other explain the fluctuations of conductivity. H. H. Ho. A

591. *Diurnal Variation of the Potential Gradient of Atmospheric Electricity.* **S. J. Mauchly.** (Terrest. Magn. 28. pp. 61–81, Sept., 1923.)—Potential gradient data, obtained over the oceans aboard the non-magnetic A ship *Carnegie* during the year ending November 1921, are analysed. They support the results obtained from earlier data regarding the predominance over the oceans of a 24-hour " wave " which reaches its maximum everywhere at the same instant, as distinct from progressing according to local time. Data from land stations are also considered, and, though large local disturbances are indicated, there is evidence that the effect is world-wide. The time of maximum development varies with time of year between the limits 16 h. and 19 h. G.M.T. The average amplitude is about 20 per cent. of the daily mean. The changes throughout the year can, with present data, be considered only for the Pacific Ocean, and here the amplitude of the 24-hour " wave " is considerably reduced in the northern summer, and a 12-hour " wave " develops with amplitude 70 per cent. of that of the 24-hour " wave." Whether the 12-hour wave over the oceans progresses according to local time or not cannot yet be determined. M. A. G.

DISCHARGE AND OSCILLATIONS.

592. *Scattering of Low-Speed Electrons by Platinum and Magnesium.* **C. Davisson** and **C. H. Kunsman.** (Phys. Rev. 22. pp. 242–258, Sept., 1923.)—Electrons from a tungsten filament were accelerated with voltages up to 1000 and a restricted beam was directed against a platinum target at 45° incidence. The number of scattered electrons with over 0·9 of the energy of the primary electrons was determined for various directions by measuring the current to a Faraday box-collector which could be revolved so as to explore the range from within 15° ($\psi = 15°$) of the primary beam to the plane of the target ($\psi = 135°$). For bombarding potentials up to 200 volts the intensity of scattering decreases more or less regularly from high to low values of ψ, indicating a maximum when $\psi = 0$. At higher potentials the scattering pattern develops two well-marked " lobes " besides the one for $\psi = 0$. When the platinum target was covered with a deposit of magnesium the patterns formed are simple. Theoretical explanations are advanced to account for these observations and estimates formed of the arrangement of the electrons in the magnesium atom. A. B. W.

593. *On the Motions of Electrons in Gases.* **K. T. Compton.** (Phys. Rev. 22. pp. 333–346, Oct., 1923.)—In this paper are presented some characteristics of electron motions in gases in an electric field, with some applications to experimental results and a discussion of the conditions in which the method is inapplicable. Cases are considered generally in which the gas pressure is sufficiently large, in comparison with the electric field, to make the average speed gained between successive collisions small compared with the total speed. For electron speeds below a critical value characteristic of each gas, the collisions with molecules are probably as between elastic spheres, since neither ionisation nor radiation is produced. The average fraction of its energy lost in elastic collision with a molecule of mass M, by an electron of mass m, is $f = 2\,(m/M)(1 - \Omega/U)$, where Ω and U are the average kinetic energies of molecules and electrons. But while, if $U > \Omega$, the electrons lose energy at collisions, they gain energy from the field between collisions, so the kinetic energy tends to increase or decrease to a terminal energy. Assuming Langevin's equation for mobility, U_t (in volts) is found equal to $0 \cdot 66\,El/\sqrt{f}$, where El is the product of field strength and mean free path. In the case of plane parallel electrodes the number of collisions per cm. and also the ratio of the speed at any point to the terminal speed, are both found to be independent of the field strength. In the case of a straight filament kathode surrounded by a coaxial cylindrical anode, the electrons may acquire their maximum speed near the kathode and subsequently lose speed while approaching the anode, their speed being greater than the terminal speed for this region. Curves are given for various cases. Substituting the value of terminal speed in Langevin's equation leads to the following expression for electron mobility: $\mu = 0\cdot 815 l\sqrt{(\frac{1}{2}e/m)}/[\frac{1}{2}\Omega + (\Omega^2/4 + W^2)^{\frac{1}{2}}]^{\frac{1}{2}}$ where the energy due to the field is $eW = le\,E/1\cdot 506\sqrt{f}$. This expression is somewhat similar to that given by Loeb (corrected for numerical error) but leads to values 0 to 10 per cent. higher. When the collisions are inelastic the mobility is shown to be greater. H. H. Ho.

594. *Mobilities of Electrons in Gases.* **K. T. Compton.** (Phys. Rev. 22. pp. 432–444, Nov., 1923.)—In a preceding paper [see preceding abstract] the nature of the motions of electrons in gases in an electric field was considered with reference to the energy lost at collisions, the terminal speed acquired, the number of collisions made, and the average rate of drift in the direction of the field. Particular attention was given to collisions between electrons and molecules treated as if between elastic spheres, and the object of the present paper is to compare the consequences of this theory with the results of experimental determinations of electron mobilities in gases. The theoretical equation for mobility constant obtained in a recent paper, is put in the form:

$$K = 2\cdot 54(10^5)l_0\{1 + [1 + 1\cdot 355(10^6)Ml_0^2(E/p)^2]^{\frac{1}{2}}\}^{-\frac{1}{2}},$$

where l_0 is electronic mean free path at 1 mm. press., M is the mol. wt. relative to H, E is the electrical field in volts/cm., and p is press. in mm. Hg; and it is tested by comparison with recent experimental data obtained by Loeb [see Abstract 984 (1922)], Townsend, etc. Although the equation contains no arbitrary constant if l_0 is taken from kinetic theory, the agreement with experiments is good in the case of H_2, and within a small factor in the cases of He, N_2 and A, for values of E/p less than the critical value which is characteristic of each gas and equal to about 20 for H_2, 1·3 for N_2, 0·5 for A, and $>0\cdot 4$ for He. Dealing with the elasticity of collisions, it is suggested that when electrons collide at speeds greater than the critical for the gas, the collisions are no longer perfectly elastic, as assumed by the theory. In the region of elastic collisions, the equation may be used to compute the actual equivalent mean free paths for elastic spheres from the measured values of K, for comparison with the kinetic theory values of l_0. This free path in H_2 is close to the kinetic theory value, in He it is a little less, while in N_2 and A it is greater and varies with the speed, being greater at small speeds. These free paths are compared with values determined in other ways and the differences are attributed to differences in the meaning attached to the term collision. The data for O_2 and CO_2 are insufficient to give the values of the critical E/p, but indicate that these are lower than for the other gases. H. H. Ho.

595. *The Photoelectric Effect of Cæsium Vapour.* **J. Kunz** and **E. H. Williams.** (Phys. Rev. 22. pp. 456–460, Nov., 1923.)—The present paper continues previous work (Phys. Rev. 15. 550. 1920) and deals with the long wave-length limit for photoelectric emission from cæsium vapour. Using a special quartz tube and taking precautions to avoid photoelectric emission from the electrodes, a narrow beam of nearly monochromatic light of gradually decreasing wave-length, was focused on the hot cæsium vapour, and it was found that above 3220 Å. the emission was zero, between 3220 and 3145 Å. the emission changed linearly because of the width of the slit used, and below 3145 Å. the emission was practically constant. The mean, 3180 Å. is taken as the critical wave-length. This is evidently identical with the convergence wave-length 3184·28 Å., which is related to the ionisation potential V_i according to the equation $V_i = hc/e\lambda_i$. It is concluded that the separation of an electron from a cæsium-atom requires the same amount of work whether produced by an impinging electron or by absorption of light. H. H. Ho.

596. *Experiments on Large Ions in Air.* **J. J. Nolan** and **J. Enwright.** (Roy. Irish Acad., Proc. 36. pp. 93–114, July, 1923.)—In this paper are recorded experimental results on the origin, constitution, and behaviour of the large ion in air. The work deals principally with the effect on the large ions of certain substances such as SO_2 and NH_3, with the effect of temperature, with the decay of large ions by combination with small ions, and with the occurrence of multiple charges. The ions dealt with in the experiments are almost exclusively those produced by ordinary Bunsen flames. Ammonia, as also found in the case of the hydrogen flame, cannot act as a starting-point for nucleation. SO_2 and NH_3, if supplied to the flame or subsequently to the flame-gas, cause the ions to grow beyond their normal size and the transition is not gradual but abrupt. When the alteration is produced by the action of the gases on the ions already formed, there is a reduction in the number of ions. With NaCl the number of ions is increased, but whether due to the NaCl supplying extra nuclei or extra ions to the flame, is not clear, although the unsymmetric character of the increase suggests the latter alternative. The idea of the large ion as a rather loose group, originally suggested by de Broglie and adopted to explain certain mobilities observed, is practically compelled by the observations of recombination between large and small ions. The units out of which the ions have been assumed to be built, the various homogeneous groups of ions which in so many cases accompany the final more stable body, reappear when the ion breaks up under the action of high temperature. The further complex stages observed in the case of phosphorus ionisation appear when the ions are affected by the presence of SO_2, NH_3, or NaCl. The large ions present in the atmosphere are possibly in great part produced by the action of ultra-violet light on the moist gas. They carry single electronic charges, and their constant of combination with small ions is between 5 and 10×10^{-6}. H. H. Ho.

597. *Absolute Mobilities of Negative Ions in Air.* **L. B. Loeb.** (Frank. Inst., J. 196. pp. 537–546, Oct., 1923.)—Although it appears as if the Rutherford alternating-current method of measuring the mobilities of negative ions was capable of yielding the greatest accuracy of any of the methods used, the values of the mobilities thus far obtained by this means show variations which are far greater than are to be expected from the errors entering into the measurement. Thus in some very careful measurements made in 1910 Kovarick found a mobility of negative ions of 2·06 cm./sec. volt/cm.; while the value obtained by Franck and Pohl, and since then by other workers generally lay close to 1·8 cm./sec. More recently the writer found that the mobilities of the negative ions measured directly on photo-electrically generated ions was 2·18 cm./sec., while the mobilities of the negative ions generated by polonium in an auxiliary chamber lay close to 1·84 cm./sec., the conditions being otherwise the same. Investigation showed that the difference in mobility lay in the use of the gauze and auxiliary field and not in the nature of the ionising agent. Various methods are discussed, and it is agreed that the Rutherford method with photoelectric ions is free from many uncertainties prevalent with the others. The experimental arrangement used is described. Its chief defect appears to be the difficulty of obtaining strict parallelism of the plates. The value of the mobility now obtained in fields varying from 12·5 volts to 50 volts/cm., in frequencies varying from 14 cycles per sec. to 75 cycles per sec., and with plate distance lying between 1·4 and 2 cm., at 760 mm. pressure is 2·18 cm./sec. volt/cm. The greatest uncertainties lie in the evaluation of the plate distance where the plates are not quite parallel. This introduces an uncertainty of ± 3 per cent. The estimation of the voltage intercept is not certain to an accuracy greater than 0·3 volt. Errors of ± 1 per cent. due to timing, of from 0 to ± 2 per cent. on account of the distance gone as an electron and perhaps of ± 2 per cent. in the conversion and correction of the potentials between the plates must also be considered. Taking into account the variety of conditions under which these results are obtained, the mobility of the negative ion may be stated as 2·18 ± 0·04 cm./sec. volt/cm. in place of the value of 1·8 cm./sec. usually assigned to it. Other work is in progress. A. E. G.

598. *Ionic Mobilities in Air and Hydrogen.* **J. J. Nolan.** (Roy. Irish Acad., Proc. 36. pp. 74–92, Jan., 1923.)—The work described in the present paper consists for the greater part of a careful examination by the Rutherford-Franck method of the ionic mobilities in hydrogen. As certain emendations and additions can be made to the results for air previously reported [Abstract 1358 (1922)], and as it is necessary to deal with criticism which some of this work has received, the first part of the paper has been devoted to ionic mobilities in air. The composite character of ionisation in air is now shown by a third method based on an alternating-field with variable periodic time. An attempt made to detect the very mobile ions in ordinary undried air was successful. An examination of the ionisation in hydrogen not specially dried or purified gave results closely related to those already found for air, and in many respects identical with those obtained by Haines for very pure and freshly prepared hydrogen. All his ions have been found except his fastest, and that was hardly to be expected, since no special measures for purity or drying were adopted. The results of the author on air and hydrogen involve, first, the composite character of the ordinary ionisation, and, second, the existence of small numbers of ions of high mobility. Criticisms of Blackwood in connection with results obtained by the author's air-stream method are considered and refuted. H. H. Ho.

599. *Variation with Pressure of the Residual Ionisation of Gases.* **H. F. Fruth.** (Phys. Rev. 22. pp. 109–121, Aug., 1923.)—The measurements made by K. M. Downey for air, using a steel sphere of one foot inside diameter, have been extended to pressures of 75 atmospheres. (1) *Purified Gases.*—Air and oxygen gave curves for ionization *vs.* pressure, first slightly concave upwards (1–15 atm.), then concave downwards (15–35 atm.), then concave upwards (35–53 atm.), then horizontal, the values increasing from 8–10 ions/c.c./sec. at 1 atm. to 62–68 for 60 atm. For CO_2 the horizontal part was reached at 61 atm., the limiting value being 97 ions/c.c./sec. (2) *Gases containing dust and water-vapour* gave similar curves except that the ionisation did not reach a limiting value but continued to increase. (3) *Anomalous Behaviour of Nitrogen.*—When prepared from air by the liquefaction process, or by absorption of the oxygen by alkaline pyrogallate, nitrogen showed no upper limit with increasing pressure, either alone or when mixed with oxygen, although air showed this limit. Evidently the process of preparation used either introduced some long period radio-active impurity or gave the nitrogen some peculiarity, such as a tendency to ionise spontaneously. (4) *Penetrating radiation* can apparently be responsible for only a small part of this ionisation, not more than 1 ion per c.c. per atm. per min. as otherwise it would not reach a limit and would not depend so much on the purity of the gas. AUTHOR.

600. *Resonance and Ionisation Tensions.* **N. Semenoff.** (Zeits. f. Physik, 19. 1. pp. 31–34, 1923.)—Points out an error involved in assuming that electrons come to the same potential as the grating or gauze which they reach. In the meshes there are [compare Abstract 124 (1924)] regions whose potential is lower than that of the metal gauze. A. D.

601. *The Excitation and Ionising Tensions of Neon and Argon and their Connection with the Spectra of these Gases.* **G. Hertz.** (Zeits. f. Physik, 18. 6. pp. 307–316, 1923.)—The method of carrying out the experiments is fully described. Diagrammatic results are given of measurements obtained in Neon at 0·51 mm., in Argon at 0·35 mm., and in a neon-helium mixture containing 30 per cent. helium at a pressure of 0·56 mm. With respect to the first excitation tension of helium at 19·75 volts, it is found that in neon there are two well-marked excitation tensions at 16·65 and 18·45 volts, and the ionising tension at 21·5 volts; for argon two excitation tensions at 11·55 and 13·0 volts and a less well-marked one at 14·0 volts, and the ionisation tension at 15·3 volts. A. E. G.

602. *The Origin of Ions in the Unsustained Glow Discharge.* **K. T. Compton** and **T. E. Foulke.** (Gen. El. Rev. 26. pp. 755–757, Nov., 1923.)—In this paper it is shown that there are sufficient residual ions present in any gas to start a discharge when a sufficiently high voltage is applied. It is found experimentally that the essential number of original ions in a discharge tube of the type studied, which consisted of concentric cylinders of nickel in mercury-vapour, are due to the radiation from the radioactive elements in the earth. The reasons for assuming this are: (*a*) By shielding the tube with lead the number of ions generated can be reduced to a value insufficient to start the discharge. (*b*) The discharge can be aided by exposing the tube to a source of radioactive emanations. The results obtained on the time-lag between the application of the voltage and the starting of the discharge were measured by means of a string oscillograph which is described; these results are in agreement with the view that the ions are formed due to the earth's radiation and that the multiplication to discharge value can readily be explained by means of Townsend's theory. Attention is drawn to the application of the Einthoven galvanometer for registering minute currents for very short intervals of time. Oscillograms are included in the paper. H. H. Ho.

603. *Kathode Fall, Ionisation Potential, and Atomic Weight.* **A. Günther-Schulze.** (Zeits. f. Physik, 20. 3–4, pp. 153–158, 1923.)—In a recent publication on the laws of the glow discharge [see next abstract] the author has shown that a pronounced parallelism exists between the normal kathode fall of the gas and its electronic affinity, but that such connection does not extend to the vapours of Rb, Cs, Zn, Cd, and Hg, which exhibit a much higher kathode fall in accordance with their small electronic affinity. The present paper contains the attempt to define this regular connection more closely. It has been established that for all gases the expression, $V_n = (0 \cdot 245M + 4)V_i \, . \, \alpha$ volts, approximately holds good, where V_n is the average kathode fall, M the atomic weight, V_i the ionisation potential of the gas, and α a factor which is unity for all monatomic gases, but has to be calculated for diatomic gases from impact effects. The extent of ionisation by a kation is inversely proportional to the square of its atomic weight to a first approximation. H. H. Ho.

604. *The Laws of the Glow Discharge.* **A. Günther-Schulze.** (Zeits. f. Physik, 20. 1. pp. 1–20, 1923. From the Reichsanstalt.)—The object of the present paper is to derive the laws prevailing at the glow discharge by a combined experimental and theoretical investigation [see Abstract 659 (1911)]. Definite values for the 3 magnitudes of the glow discharge: the normal kathode fall V_n, the normal current density j_n, and the normal fall-space thickness, could only be obtained, however, for plane kathodes maintained at constant temperature. The normal kathode fall V_n for any metal in any gas has afforded the empirical equation, $V_n = -35 \cdot 5 \, . \, \epsilon_h + a$, where ϵ_h is the electro-chemical normal potential. The optically measured fall-space thickness for any metal in any gas is $(d_{Me})_{\text{opt.}} = 0 \cdot 326 \, . \, \lambda \, . \, V_i \, . \, V_{Me}^{7/4}/p$ cm. The electrically measured fall-space thickness is $(d_{Me})_{el} = 1 \cdot 15 \, . \, (d_{Me})_{\text{opt.}}$. For the relationship between V_n, j_n, and d_n, at plane kathodes, the space charge equation:

$$j_n = \frac{\sqrt{2}}{9\pi} \sqrt{\frac{\epsilon}{M}} \frac{V_n^{3/2}}{(d_{Me})_{el}^2}$$

holds approximately, where ϵ is the electronic charge, M the atomic weight of the gas concerned, V_n the derived kathode fall, and $(d_{Me})_{el}$ the value obtained from the above formula. In the region of the anomalous kathode fall, $V_a = C \, ; \, \sqrt[4]{j_a}$ and $d_a = C_2 \, . \, j_a^{-\frac{1}{2}}$, where V_a, d_a, j_a are the terms of the anomalous kathode fall, C_1 and C_2 being constants. H. H. Ho.

605. *The Glow Electronic Emission at Transition and Melting-Points.* **A. Goetz.** (Phys. Zeits. 24. pp. 377–396, Sept. 15, 1923.)—The first part of the paper contains a discussion of known changes in the electrical behaviour of metals at transition and melting-points with respect to conductivity, thermal, and photo-electrical effects. Following this comes the description of the construction of a high vacuum furnace which permits the measurement of the glow emission of metals at these modification points [see Abstract 923 (1912)]. A method of measurement is given which enables the construction of the Richardson lines from the characteristics. For copper, iron, and manganese an appreciable increase in the exponential constants of the Richardson law occurs at the melting-point, without the appearance of any discontinuity in the emission. At the transition of iron from the γ to the δ state, a change takes place in the constants N of the Richardson law, while the exponential constants undergo no appreciable alteration. For the iron measurements the position of the magnetic transition point found by Curie is confirmed with greater probability. In the magnetic field of the furnace the glow emission shows a slight diminution of the exponential constants. γ-iron exhibits an appreciably greater ability to take up gases than δ-iron, a procedure which is connected with the content of conducting electrons in the space lattice. For manganese the probable existence of a transition point of magnetic character appears at about 1200°. From the experimental results taken in conjunction with those from Suhrmann's investigations, the assumption is made that the conductivity electrons in the space lattice of the metal are arranged in any order. Measurements at the melting-point cannot be explained on the kinetic electronic theory corresponding to the Richardson view point. H. H. Ho.

606. *Canal Rays.* **W. Wien.** (Phys. Zeits. 24. pp. 415–420, Oct. 1, 1923. Paper read before the Deut. Physikertag., Bonn, Sept., 1923.)—Various kinds of apparatus for the study of canal rays is described in detail with the aid of diagrams. Some experimental results are illustrated photographically, others by diagrams. It is shown that the reciprocal of the free path of the uncharged atom of hydrogen depends on the pressure. A spectral line sent out by a charged atom undergoes deflection in an electric field. The Balmer series of hydrogen (Hβ) are not deflected, while the spark lines of oxygen are deflected. In the same manner a deflection occurs of a series of nitrogen lines and also the so-called negative bands which according to this are emitted by positively charged nitrogen molecules. The electric deflection depends only upon the tension of the discharge tube, and so it cannot be decided through these deflections whether results from single or several charged atoms are being observed. A. E. G.

607. *Loss of Velocity of Kathode Rays in Matter.* **H. M. Terrill.** (Phys. Rev. 22. pp. 101–108, Aug., 1923.)—Whiddington's apparatus was modified to provide a bundle of homogeneous rays by fitting a Coolidge kathode into a high-vacuum tube and exciting it by rectified high-tension current of accurately known voltage. After traversing the metal foil, the electron beam is deflected by the magnetic field of a solenoid and is spread into a broad band of which a small section, deflected about 30°, passes through a fixed slit into a Faraday cylinder connected to an electroscope. By varying the solenoid current, energy distribution curves were obtained, and the most probable energy loss for each case was determined from the position of the maximum. Rolled foils of Ag, Al, Au, Be, and Cu were studied, for 25 to 51 kv., giving rays of 9 to 12·6 × 10^9 cm./sec.

velocity. The results agree with the velocity formula of J. J. Thomson, $v_0^4 - v_x^4 = ax$, where x is the thickness, and a is a constant which comes out proportional to the density of the metal so that $a/\rho = 5\cdot05 \times 10^{42}$ approximately. In the corresponding voltage formula $V_0^2 - V_x^2 = bx$, $b/\rho = 0\cdot40 \times 10^{12}$. AUTHOR.

608. *A New Effect of the Magnetic Field upon the Discharge in Rarefied Gas.* **A. Pontremoli.** (Accad. Lincei, Atti, 32. ii. pp. 158–161, Sept., 1923.)—The experiments of Steubing and Wood have shown that a magnetic field of sufficient intensity causes the disappearance of the resonance spectra. Various theories to account for this phenomenon are discussed and experiments described in which the apparatus used differs only very slightly from that of Wood [see also Abstract 1440 (1921)]. A. E. G.

609. *A Glow Discharge Rectifier for Alternating Current.* **H. Kneser.** (Ann. d. Physik, 72. 7. pp. 519–524, Nov., 1923.)—The rectifier has a large cylindrical electrode A, and in the axis of the cylinder a small rod electrode ; both electrodes are of aluminium. The tube was supposed to be filled with a mixture of He and Ne ; but traces of H, Xe, and Hg were found spectroscopically. With 140–160 volts (effective) a c.c. galvanometer in series with the rectifier gives a deflection, the current passing from the large to the small electrode. At higher voltages the direction of the current reverses and becomes much greater. The characteristic curves of the rectifier have been determined, and are given in the original paper. When a constant negative voltage is applied to the small electrode a brush discharge takes place from it, and no other light is seen ; this does not alter up to 300 volts, if on the other hand the small electrode is positive, 240 volts is not sufficient to produce a positive brush discharge from it. At 240 volts discharge takes place, changing at once to a glow discharge, with normal kathode fall, and continuing with high current values at considerably reduced voltage. The instantaneous values of the current were obtained by means of a Braun tube, and moving photographic plate ; they rise to a high value at the moment when the small electrode has the maximum positive voltage, and rapidly drop to zero ; half a period later a small current is produced for a short time in the opposite direction, and during a considerable portion of each period the current is practically zero. A choking coil reduces the maximum value of the instantaneous current, but increases the portion of the period during which the positive current flows. Photographs are given of the appearance of the electrodes under different conditions. From these it appears that the small electrode gives a negative brush discharge each time its voltage passes through the maximum value, while the large electrode gives the glow discharge half a period later. H. N. A.

610. *The Current-Density of Normal Kathode Falls.* **A. Günther-Schulze.** (Zeits. f. Physik, 19. 5–6. pp. 313–332, 1923. From the Reichsanstalt.)—It is concluded that the relation between the normal current-density of the glow discharge and the gas pressure can be defined when the following conditions are fulfilled. The walls of the discharge-vessel must be so far removed from the discharge path that no disturbing positive light column originates. The volume of the vessel must be large compared with that of the fall space. The anode must so surround the kathode that all parts of the latter are equidistant from the anode. A platinum electrode when completely covered with the discharge assumes in air at 5·26 mm. pressure at normal current-density, an end-temperature of 500° C. The velocity with which the temperature rises depends on the capacity for heat and volume of the kathode. At 5 mm. pressure the normal current-density at a platinum kathode, cooled and kept at room temperature, is found to be 2·8 times as great in hydrogen and 6·3 times as great in air as at a kathode at its end-temperature. The normal current-density at a kathode at constant temperature is $J_n = C \, . \, p^2$, with a kathode at end-temperature there is no simple connection between J_n and p. Different forms of kathode of equal surface, and kathodes of different metals are also investigated. [See also Abstracts 1926 and 2475 (1923).]

A. E. G.

611. *The Removal of Thorium from the Surface of a Thoriated Tungsten Filament by Positive Ion Bombardment.* **K. H. Kingdon and I. Langmuir.** (Phys. Rev. 22. pp. 148–160, Aug., 1923.)—The disintegration of the kathode in an electric gas discharge tube by the impact of positive ions on its surface is a subject which received some considerable attention during the early years of research in gaseous conduction. The main results obtained have been summarised by Kohlschutter and J. J. Thomson. It was found that for all ions the rate of disintegration or sputtering increased with the energy of the ions, that is with the voltage across the tube—or more particularly with the kathode fall. For a kathode of Pt the rate of sputtering was found in general to increase with the mass of the ion. For a given ion, say argon, the rate of sputtering tended to be less the lighter the kathode material, and for this reason aluminium electrodes are usually employed in spectrum discharge tubes. The present experiments are based upon the fact that the removal of thorium from the surface of a thoriated tungsten filament by the impact of positive ions is a special case of kathode sputtering, and one which is admirably suited to a precise examination of the mechanism of the disintegration process. Langmuir has shown that by subjecting a tungsten filament containing a small percentage of thorium oxide to suitable thermal treatment it is possible to obtain a complete layer of thorium one atom deep over the surface of the tungsten. At a temperature of 1500° K. the electron emission from this thorium surface is about 100,000 times that from an equal area of pure tungsten. Hence removal of thorium from the surface by ion bombardment or otherwise exposes the tungsten underneath and decreases the electron emission of the filament. The connection between the fraction of the surface covered by thorium and the electron emission has been studied in detail by Langmuir so that this provides an exceedingly delicate method for studying the removal of minute quantities of thorium from the surface. The type of vacuum tube used is described. The rate of removal of thorium falls to zero for all gases at about 50 volts, a fact of significance in connection with the theory here described.

A. E. G.

612. *Thermionic Emission.* **A. Pontremoli.** (Accad. Lincei, Atti, 32. ii. pp. 211–214. Oct., 1923.)—Following up the work of M. N. Saha [see Abstracts 218, 384 (1921] and of Dushman [see Abstract 310 (1924)], the latter of whom reached Richardson's formula $I = AT^2\epsilon^{-b_0/T}$ and found A to be a constant for all elements (a function of universal constants) but left b_0 unexplained physically; the author finds $b_0 = \epsilon V/k$, where V is the ionisation-potential and k is the thermodynamic constant per single molecule. The formula reached by the author is $I = \{2\pi m\epsilon k^2/h^2\} . T^2 . \epsilon^{-\epsilon V/kT}$, where h is Planck's constant. A. D.

613. *Electron Emission from Thoriated Tungsten Filaments.* **I. Langmuir.** (Phys. Rev. 22. pp. 357–398, Oct., 1923.)—This paper describes an extensive series of experiments on the properties of thoriated tungsten filaments. By suitable treatment filaments containing 1 or 2 % of thoria can be made to give an electron emission many thousand times that of a pure tungsten filament at the same temperature. The experimental results lead to the conclusion that the increased emission is due to a layer of thorium atoms adsorbed on the surface of the tungsten. To form this layer, the thorium oxide, which originally existed throughout the volume of the filament, must first be reduced in part, by heating for a few seconds to between 2600° and 2800°K.; then, by heating for some time at a suitable activating temperature 2000° to 2100° K., some of the thorium atoms are brought to the surface by diffusing faster than they evaporate, the fraction θ of the surface covered increasing to a limit θ_∞ which may or may not be unity. The activity determined at a lower testing temperature 1400° to 1500° K. increases logarithmically with θ; for any filament it remains constant provided the filament is not heated above 1900° K. and the film is not allowed to be oxidised. The rate of activation depends on the difference between the rate of diffusion to the surface and the rate of evaporation from the surface. Experiments are described relative to these, and the results obtained for the coefficient of diffusion are in agreement with a theoretical expression given by Dushman and Langmuir. Various properties of thoriated tungsten filaments are summarised in a table, and the paper concludes with a brief discussion of these properties. A. W.

614. *Currents Limited by Space Charge between Coaxial Cylinders.* **I. Langmuir** and **Katharine B. Blodgett.** (Phys. Rev. 22. pp. 347–356, Oct., 1923.)—The authors calculate the function $\beta = f(r/r_0)$ in the space charge equation $i = (2\sqrt{2}/9)\sqrt{(e/m)}V^{3/2}/(r\beta^2)$. Two different infinite series were obtained for B and the coefficients for fourteen terms of each were determined. These two sets were checked against each other. Thus values of β^2 were obtained accurate to 1 in 10,000. These were checked by an integration method which was also used to calculate values in the region where the series failed. For a kathode of radius r_0 inside an anode of radius r, β^2 increases from 1 at $r/r_0 = 11{\cdot}2$ to a maximum value 1·0946 at $r/r_0 = 42$, decreases to a minimum value 0·9990 at $r/r_0 = 30{,}000$, and becomes 1 at $r/r_0 = \infty$. The customary assumption $\beta^2 = 1$ has therefore led to errors up to 9·5 per cent. in previous calculations, but this error is usually about equal and opposite to that introduced by neglecting the effect of initial velocities. For the kathode outside the anode, β^2 is given very closely by the equations $\beta^2 = 4{\cdot}6712\,(r_0/r)\,[\log_{10}(r_0/r) - \log_{10}\sqrt{2}]^{3/2}$, for $r_0/r > 10$. The empirical constant $\sqrt{2}$ is interpreted to mean that the potential distribution near the anode is unaltered if the hot kathode is replaced by a cold cylinder having one half the cross-section of the original kathode. The correction for initial velocities is less for a cylindrical kathode inside an anode than for parallel planes. In the inverted case it is much greater than in the case for parallel planes, and the effect of the tangential component of the initial velocity may greatly decrease the current that flows. AUTHORS.

615. *The Low-Voltage Arc Light in Helium.* **R. Bär, M. v. Laue** and **E. Meyer.** (Zeits. f. Physik, 20. 2. pp. 83–95, 1923.)—It is shown that with a direct-current tension of less than 20 volts an arc light burning in helium can be brought to the condition that oscillations are present in the arc, which from time to time raises the tension at the electrodes to over 20 volts. It is also shown that a slight strengthening of the glow current causes a strong lowering of the tone; a strengthening of the arc-light current causes a lowering of the tone; an increase of the electrode distances causes a decrease of the arc current and a rise in the tone; a rise in the He-gas pressure causes a lowering of the tone. A description, with diagrams of the apparatus used, is given. A. E. G.

616. *Experiments on the Electric Arc.* **M. Pierucci.** (N. Cimento, 26, pp. 73–96, July–Aug.–Sept., 1923.)—The experiments here described are divided into two sections and are along the lines of those described by Beer and Tyndall, etc. [see Abstract 2130 (1922)] in which carbon electrodes are used, drilled centrally throughout their length. In the first series of experiments various substances containing hydrogen in their molecules are put in the arc through the holes in the carbons. In the second series a strong suction in the arc is produced from the positive aperture. A. E. G.

617. *The Striking Potential in the Low-Voltage Mercury Arc.* **M. Scott.** (Phys. Rev. 22. pp. 447–455, Nov., 1923.)—The experiments now described were undertaken to obtain more definite knowledge concerning the characteristics of the low-voltage arc, and in particular regarding the factors upon which the striking potential depends. An effort was made to obtain as steady conditions as possible in the experimental tube with particular attention to securing gas-free apparatus, a good vacuum, and a conditioned filament that would yield a constant electron emission. Part I deals with the variation with vapour pressure. A tube with a thoriated tungsten filament and a nickel anode over a reservoir of mercury was heated in an electric furnace. When a constriction was placed in the tube leading to the pump so as practically to eliminate streaming of the vapour, and the temperature raised, the striking potential decreased to a minimum of approximately 5·3 volts for a pressure corresponding to a mercury surface temperature of 160° C., and then increased. When no constriction was present, a similar curve was obtained except that on account of the streaming the pressure for a given furnace temperature was lower, and hence the minimum was not reached below 320° C. If the fact that the vapour was fresher in the second case had any influence, it was not evident. Part II considers the variation with the distance away of the mercury surface. When streaming was prevented, the same striking potentials were obtained for the same vapour pressures whether the surface was 5 cm. or 80 cm. from the arc. These results are somewhat at variance with those of Yao and suggest that further investigation is necessary. H. H. Ho.

618. *Positive Ion Currents in the Positive Column of the Mercury Arc.* **I. Langmuir.** (Gen. El. Rev. 26. pp. 731–735, Nov., 1923.)—When a mercury arc passes through a tube of uniform diameter, as in the side arms of a mercury rectifier or in a mercury-vapour lamp, the tube is filled with a uniform glow whose intensity depends on the current-density and the mercury-vapour pressure. Practically the whole of the discharge, except in close proximity to the two electrodes, is of the type usually referred to as the positive column. If an auxiliary electrode of small size is placed in the path of the discharge and connected to an electrometer or potentiometer, it is found that it acquires a definite potential, which in accordance with common practice may be provisionally assumed to be that of the gas surrounding it, and, for convenience, may be referred to as zero potential. If the electrode be charged positively to one or two volts, a relatively large current of electrons flow to it from the gas, so that it becomes an anode sharing the current with the main anode. If the electrode be negatively charged, the current to it reverses in direction, but only a relatively small current flows, which increases, in general, slowly, if at all when the negative voltage is raised to several hundred volts, thus behaving as if it were a saturation current. This current must result from a flow of positive ions to the electrode (out of the gas) or an emission of electrons from the electrode, or from both phenomena. Such electron emission might conceivably be photoelectric emission caused by the intense ultra-violet radiation or it might result from the impact of positive ions against the electrode (delta rays). A theory is developed which explains the behaviour of these negatively charged electrodes and also gives a new conception of the nature of the mercury arc. A. E. G.

619. *The Positive Crater.* **E. Podszus.** (Zeits. f. Physik, 19. 1. pp. 20–30, 1923.)—The author has made some previous experiments and measurements of the positive crater using homogeneous carbon electrodes [see Abstract 1316 (1919)]. In the present experiments the behaviour of an arc, when pure carbon electrodes are used and longitudinal magnetic field is employed for calming the discharge, is investigated. The measurement of the surface brightness of the pure carbon under pressure, with magnetic calming, and the measurement of the size of the positive crater is also undertaken. A special arrangement is described for finding the boiling-point of the carbon at atmospheric pressure. A. E. G.

620. *Spark-Gap with Air-Cooled Electrodes.* **W. T. Bovie.** (Optical Soc. of America, J. and Rev. Sci. Inst. 7. pp. 1027–1029, Nov., 1923.)—The apparatus here described has been devised to overcome the difficulties arising through the heating of electrodes between which a powerful spark was passed. The fundamental principle is that the spark is formed between the edges of two rotating discs, thus distributing the heating effects over the whole circumference of the discs, at the same time affording ample surface for radiation. The apparatus works quite satisfactorily and is completely under control. A full description and photograph of the apparatus is given. A. E. G.

621. *Stationary Electromagnetic Waves with Undamped Emission.* **W. Kopp.** (Ann. d. Physik, 72. 7. pp. 525–548, Nov., 1923.)—The dependence of the formation of stationary waves upon the position of the emitter in a node or loop, as found by Bergmann [Abstract 1692 (1922)], is now explained for the most part as due to the influence of extra reflections in the closed space. Measurements in open space on the contrary afford only slight evidence of any such dependence and this may be recognised as a return effect of the stationary wave upon the emitter. The requisite formulæ of such waves are established for the Hertzian and Abraham sender. The curves found by experiment are similar to those calculated for proximity to the reflecting partition, but show deviations when damping takes place, which is assumed to depend on the environment. Experiments are fully described for closed and open space accompanied by 20 illustrative diagrams. H. H. Ho.

ELECTRICAL PROPERTIES AND INSTRUMENTS.

622. *The Equilibrium Theory of Electrical Conduction.* **A. T. Waterman.** (Phys. Rev. 22. pp. 259–270, Sept., 1923.)—In attempting to explain the electrical conductivity of good and of poor conductors, the electron theory has so far required quite different methods of treatment, a brief account of which prefaces the paper. It is now the author's purpose to show that, in an exceedingly natural and simple manner, it is possible to explain the temperature variation of electrical conductivity for both good and poor conductors on identically the same hypothesis for each. The theory proposed accepts the expression for the conductivity given by the simple electron theory, but, like the theory proposed by Caswell, it assumes a constant or nearly constant mean free path, and explains conductivity variations by variations in the concentration of the free electrons. Like the theory of Koenigsberger, it is based upon a chemical dissociation of atoms into ions and free electrons. (1) *General Equation.*—The concentration of free electrons is assumed to be determined by the reaction: normal atom $\rightleftarrows$ + ion + ν electrons, which is governed by the ordinary laws of chemical equilibrium, and this gives for the specific electrical resistance, $\rho = C(\nu N)^{-1/(\nu+1)}T^{a}e^{b/T}$, where ν is the valence in the reaction, N the concentration of atomic nuclei, $a = (\nu + 4)/2(\nu + 1)$, $b = (\phi_0 - \psi_0)/(\nu + 1)R$, $(\phi_0 - \psi_0)$ being the mean energy required to bring about the hypothetical reaction of 0° K. This formula shows fair quantitative agreement with experimental data for both good and poor conductors; in particular, the constant a is about 1·25 for the alkali metals and less for metals of higher valence except in the case of Fe and Ni. For the metals the requirement is that ϕ_0 be slightly less than ψ_0, while for poor conductors ϕ_0 must be considerably greater than ψ_0. (2) *Interpretation of Constant b in Terms of Photoelectric and Thermionic Work Functions.*—ϕ_0 and ψ_0 are identified with the photoelectric energy function and with the corresponding thermionic function respectively. According to the theory proposed, the ordinary expression for the thermionic saturation current becomes: $i = BT^{(4\nu+1)/2(\nu+1)}\epsilon^{-\omega/RT}$, where $\omega = (\phi_0 + \nu\psi_0)/(\nu + 1)$ in the present notation. Therefore for metals the photoelectric ϕ_0 and the thermionic ω as experimentally determined should be practically identical, while for poor conductors the experimental ϕ_0 should considerably exceed ω. These conclusions are both in agreement with the facts. (3) *Explanation of Photo-Conduction.*—This theory suggests that the mean value of ϕ_0 is diminished by absorption of radiation of the resonance frequency. For poor conductors this would bring about an increase in conductivity, while for metals at ordinary temperatures the conductivity would not be sensibly affected; at very low temperatures metals should prove photo-sensitive. H. H. Ho.

623. *The Electrical Conductivity of Metals.* **A. Schulze.** (Zeits. f. Metallkunde, 15. pp. 33–40, Feb., and pp. 155–160, June, 1923.)—Contains an account of the present state of knowledge of this subject, including the phenomena of abnormal conductivity near the absolute zero, the effects of impurities, and those of cold working and heat treatment on a large number of different metals. H. N. A.

624. *The Compressibility and Pressure Coefficient of Resistance of Rhodium and Iridium.* **P. W. Bridgman.** (Am. Acad., Proc. 59. pp. 110–115, Nov., 1923.)—The compressibility and the pressure coefficient of electrical resistance for a large number of metals have already been determined [Abstract 1698 (1922)]. The present paper contains the results for Rh and Ir. The degree of purity of the Rh was much higher than that of the Ir used, as shown by values of the temperature coefficient of electrical resistance. At 30° the compressibility of Rh is $3 \cdot 72 \times 10^{-7}$, of Ir $2 \cdot 68 \times 10^{-7}$, the pressure coefficient of resistance of Rh $- 1 \cdot 74 \times 10^{-6}$, and of Ir $- 1 \cdot 35 \times 10^{-6}$. The paper also contains a table comparing these properties with atomic weight and atomic volume for metals in three related series, *viz.* (1) Fe, Co, Ni; (2) Ru, Rh, Pd; (3) Os, Ir, Pt. The properties do not progress regularly in these series. L. L.

625. *Further Experiments with Liquid Helium. On the Electric Resistance of Pure Metals, etc. XII. Measurements concerning the Electric Resistance of Indium in the Temperature Field of Liquid Helium.* **W. Tuyn** and **H. K. Onnes.** (K. Akad. Amsterdam, Proc. 26. 7–8. pp. 504–509, 1923. Comm. No. 167a from the Phys. Lab., Leiden.)—For the further detection of super-conducting metals the behaviour of those elements has been investigated which take a place near already known super-conductors in the periodic system, and for this purpose indium, which is above thallium and by the side of tin, was chosen. Details of preparing the indium wire are given and measurements in liquid helium described, the apparatus being the same as on a previous occasion [see Abstract 1458 (1923)]. The measurements were made by compensation of the potential at the extremities of a known and an unknown resistance connected in series, by the aid of a Diesselhorst compensation apparatus free from thermo-electromotive forces. Tables of results are given. The question now arises as to whether the vanishing-point temperature has a periodic character. In the periodic system, In lies above Tl, Sn above Pb, and it is remarkable that the above temperature rises both from In to Sn, and from Tl to Pb. Towards the left, from Tl to Hg, it also ascends, and if this rise should continue, the vanishing-point temperature of Au would lie higher than that of Hg. Since Au does not become super-conducting on cooling to 1·5° K, the conclusion might be drawn that Au—perhaps with other metals—can never become so. H. H. Ho.

626. *Electrical and Thermal Properties of Iodine.* **A. Pochettino** and **G. Fulcheris.** (Accad. Sci. Torino, Atti, 58. 14. pp. 311–320, 1922–1923.)—The specific resistance of iodine was measured, using very pure powdered iodine, sublimed four times, compressed into small cylinders, having a mean density 4·7 placed between cylinders of graphite, which served as electrodes. Special care was taken to preserve the cylinders during preparation from any contact with substances with which the iodine might react. They were preserved from humidity in the air by being kept in a desiccator, and during the experiment were pressed between the graphite electrodes by means of a vice, from which the system was insulated by sheets of glass. By means of a sensitive Deprez-D'Arsonval galvanometer the current passing through the iodine from a battery of secondary cells was measured. As a secondary circuit with another galvanometer showed the existence of a thermoelectric current, due to the Peltier effect at the iodine-graphite surfaces, care was taken to determine the strength of the primary current as quickly as possible. The specific resistance of the solid iodine was found to be $113 \cdot 2 \times 10^8$ at 4°·1, and steadily decreased as the temperature rose to $1 \cdot 1 \times 10^8$ at 42°·7, the highest temperature used in the experiments.

The thermal conductivity of pure iodine in the solid state was measured, and was found to vary from 0·001006 to 0·001163, with a mean value of 0·001065 sensibly constant in the interval of temperature 24°·4–42°·86. J. J. S.

627. *The Electric Conductivity of Salt Vapours.* **G. C. Schmidt** and **R. Walter.** (Ann. d. Physik, 72. 8. pp. 565–594, Nov., 1923.)—In previous papers the conductivity of salt vapours has been investigated by Schmidt [see Abstract 1184 (1918)]. A method is here described for measuring vapour pressure, and the apparatus used in determining the conductivity of the halogen salts of Zn and Cd is dealt with in detail. It is found that the conductivity of the vapour depends very largely upon the time. In general the conductivity at the beginning increases with the time, reaches a maximum, and then begins quickly, afterwards slowly, to fall. The salt most used is CdI_2. The heated salt emits only positive ions, and this result is due to surface ionisation and not to volume ionisation. When the CdI_2 is heated on nickel or glass only positive ions are given out, as happens with Pt. The heated oxides of Cd and Zn and the metals themselves give out at relatively low temperatures neither ions nor electrons. The distillate of CdI_2 is richer in Cd than the original salt, and it becomes the more so the more often it is distilled. CdI_2 thus loses iodine, and a complex salt is formed.

A. E. G.

628. *Specific Resistance and Temperature Coefficient of Resistance of Solutions of Potassium in Liquid Ammonia.* **C. A. Kraus** and **W. W. Lucasse.** (Am. Chem. Soc., J. 45. pp. 2551–2555, Nov., 1923.)—Some additional values, agreeing with previous observations, are given for the specific resistance of solutions of potassium in liquid ammonia. The resistance temperature coefficient of concentrated solutions has been measured from a dilution of 6 litres to the saturation-point. The change of the temperature coefficient as a function of the concentration parallels that previously observed in the case of solutions of sodium.

A. A. D.

629. *Resistivity of Aluminium at Different Temperatures.* **G. Grassi.** (Accad. Sci. Torino, Atti, 58. 4–5. pp. 89–94, 1922–1923.)—Tests were made with the purest specimens of aluminium obtainable. Two samples from different sources containing 99·7 % Al gave almost identical results. The resistivity, R, at 0° is 0·02644, and the temperature coefficient, α, at 0° is 0·004270, as deduced from experiments with these specimens.

Thus the product $R\alpha = 0{\cdot}0001129$. From previous experiments by the author on aluminium of pureness less than 99 % this product was found to be little variable around the value 0·0001141. J. J. S.

630. *Electrical Resistance of Commercial Aluminium.* **L. Guillet.** (Comptes Rendus, 177. pp. 953–955, Nov. 12, 1923.)—The presence of iron and silicon in the commercial material raises the value of the specific resistance above that found for the pure metal. Silicon has a bigger effect than iron. Mechanical working does not affect the resistance to any extent. This is particularly the case for the pure material. A. A. D.

631. *The Effect of Small Temperature Variations on the Conductivity of Solid Salts, and the Influence of Moisture Thereon.* **P. Vaillant.** (Comptes Rendus, 177. pp. 637–639, Oct. 8, 1923.)—As a result of the development of his previous work [see Abstract 1700 (1922)], the author has discovered two distinct types of conductivity—temperature curves, according to the mode of preparation of the sample. If the powdered solid is mixed into a paste and then dried, the heating and cooling curves both coincide with the Richardson formula $C = aT^{\frac{1}{2}}e^{-b/T}$. The same curve is obtained when the operation is repeated whatever time has elapsed since the previous experiment. If the salt is powdered and compressed between the electrodes, or is in the form of crystalline laminæ, the conductivity first rises to a maximum and then falls off: this diminution continues on cooling until at the original temperature the conductivity is below its initial value. On repeating the operation, the conductivity curve is of the same form, but diminishes in amplitude. A further experiment shows no change in conductivity. The loss of conductivity is only momentary, and the value rapidly rises above its initial figure, when heating and cooling curves may be obtained as before, with increased magnitude.

Dry air passed over the solid salt causes a rapid decrease in conductivity, while saturated air produces a considerable increase. All these phenomena can be explained by assuming that conductivity in solid salts is due to the presence of a film of moisture at the surface whose condition will determine the value of the conductivity and its sensibility to temperature variations. B. W. C.

632. *The Effect of Tension on the Thermal and Electrical Conductivity of Metals.* **P. W. Bridgman.** (Am. Acad., Proc. 59. pp. 119–137, Nov., 1923.)—The metals investigated were Cu, Al, Fe, Ag, Pt, Pd, and Ni. These were chosen because they can be obtained in a state of purity and homogeneity and belong to the cubic system. Experiments on the change of thermal and electrical conductivity of metals when subjected to hydrostatic pressure have been previously described [Abstract 1698 (1923)] and the Wiedemann-Franz ratio found to alter with pressure. In the present investigation the specimen was in the form of a drawn rod, 15 cm. long, 3 mm. diameter, fixed in copper grips. It was hung from the ceiling by a rod fixed in the upper grip and the load was applied gradually to the lower grip by a lever device. To measure the thermal conductivity the rod was heated electrically at the middle, while its ends were water cooled. The energy input in the heater and the temperature gradient on each side of this central heating coil were measured. The electrical resistance of the specimen was determined by a fall of potential method. Except in the case of Ni, both the thermal and electrical conductivities diminish under tension. The diminution in the thermal conductivity is small, but it is greater than can be accounted for by change of dimensions due to tension. The table gives a summary of results.

Metal.	Load. kg./cm.^{2}.	Per cent. Change of Conductivity.		Proportional Change of Specific Conductivity per kg./cm.^{2}.*	
		Thermal.	Electric.	Thermal $\times 10^6$.	Electric $\times 10^6$.
Al	545	− 0·34		− 3·8	
	393		− 0·165		− 1·8
Cu	1080	− 0·34	− 0·327	− 2·1	− 1·7
	580		− 0·154		− 1·3
Fe	2050	− 0·534	− 0·518	− 1·90	− 1·82
	1025	− 0·32	− 0·257	− 2·37	− 1·80
Pd	770	− 0·133	− 0·235	− 0·20	− 1·52
	457		− 0·146		− 1·66
Pt	790	− 0·189		− 1·35	
	770		− 0·209		− 1·67
	458		− 0·119		− 1·56
Ag	790	− 0·23 − 0·33		− 1·2	
	770		− 0·43		− 3·4
	460		− 0·23		− 2·8
Ni	1900	+ 0·076	+ 0·48	+ 0·48	+ 3·3

* Corrected for dimension changes under tension.

The changes of electrical conductivity under tension are of the same order as those found by Tomlinson for these metals. The thermal effects are, however, different in sign to those obtained by previous observers.

The results are then discussed from the point of view of the classical electron theory. This requires constancy of the Wiedemann-Franz ratio and is therefore insufficient. In the opinion of the author the atom plays a part in the mechanism of conduction amounting probably to one-third of the whole in the case of thermal conduction. He conceives the electrons as moving in "grooves" through the atoms—their motion is restricted. The effects of hydrostatic pressure and tension on their "free paths" would not be the same. Pressure would lengthen all free paths, tension, only those in its direction, the others being shortened. Roughly the experimental results conform with these conceptions. L. L.

633. *Thermoelectric Properties of Sputtered Films of Gold Platinum and Palladium.* **R. M. Holmes.** (Phy. Rev. 22. pp. 137–147, Aug., 1923.)—The thermoelectric properties of kathodically deposited films are studied over the range 0 °C. – 300° C. The e.m.f. obtained from a pair of films in contact is usually much less than that obtained from the corresponding solid metals. The position of the neutral point is also altered. As the films differ structurally from the mother metals thermo-currents can be obtained from a film in contact with its parent metal.

Several such couples are studied. In all cases baking at 500° C. diminishes the e.m.f. obtained. In the case of palladium, mono-metallic couples have been investigated, one element consisting of a film containing occluded hydrogen the other element being gas free. Baking at 500° C. removes the effects observed. A simple electronic theory is developed to explain the results obtained in this case. There is fair agreement between theory and experiment. A. A. D.

634. *Influence of Occluded Hydrogen on the Resistance of Platinum.* **R. Suhrmann.** (Zeits. f. Physik, 19. 1. pp. 1–16, 1923.)—The effect of occluded hydrogen on the resistance of platinum foil is here investigated over the range 400° C.–1600° C. Two foils were used. The first was "gassed" by heating in an atmosphere of hydrogen, and the second electrolytically. The foils were then heated *in vacuo*, observations of resistance being made as the hydrogen was driven off. The two foils behaved in an analogous manner. At any given temperature there is, at first, an increase of resistance as the gas is evolved, followed by a diminution. The effects appear to be more marked at the lower temperatures.

The problem is complicated by the fact that structural changes occur in the platinum as a result of heating. To separate the change of resistance due to this cause, from that due to loss of hydrogen, observations were made on the radiating power and photoelectric properties of the foil. The former is only affected by structural alterations and the latter by loss of gas. In this way the two effects can be separated. A. A. D.

635. *Electric Conductivity and other Properties of Reguline Lead Peroxide.* **W. Palmaer.** (Zeits. Elektrochem. 29. pp. 415–428, Sept., 1923.)—Some dark-coloured metallic oxides and sulphides, especially if of metallic lustre, conduct the current fairly well like metals. Natural crystals vary much in this respect owing to the accidental distribution of impurities, often finely disseminated. The author prepares reguline lead peroxide in layers of 1 cm. thickness after Ferchland by depositing the peroxide on carbon from aqueous lead nitrate. The peroxide was dark brown or black-grey, of metallic lustre and brittle, chemically very pure, free of nitrate, but contained 0·002 % MnO_2 and more moisture and oxygen, which cannot be expelled by heat; the hydrate H_2PbO_3 was not found; density 9·36 at 15°; hardness 5 to 6; specific heat 0·064 (between 20° and 100°); molecular heat 15·24 at 60°. For the conductivity determination a rod of the peroxide is clamped between copper plates and suspended by two platinum wires, fitting into grooves near the ends of the rod; these wires are connected to an electrometer; the rod is weighted during the test. The corrections required are discussed. The specific resistance is $w_0 = 0 \cdot 000091$; the resistance decreases between 20 and 84° at the rate of 0·06 per 1° C. The conductivity is higher than that of mercury and bismuth. H. B.

636. *Spectro-Photoelectric Effects in Argentite and the Production of an Electromotive Force by Illumination.* **P. H. Geiger.** (Phys. Rev. 22. pp. 461–469, Nov., 1923.)—Brown, Sieg, Pfund, Coblentz, etc., have studied the change of resistance of various substances, notably selenium, with change of illumination, and Case [see Abstract 669 (1917)] found about

20 different crystalline substances which show an increase in conductivity with illumination. The present investigation was undertaken with the purpose of studying the electrical and photoelectrical properties of argentite (Ag_2S), when a new and unexpected property was revealed in that if argentite be connected in a closed circuit with a galvanometer and one surface of contact is illuminated, then an e.m.f. is produced which increases with the intensity, reaching a limit of about 0·013 volt for 600 candle-metres and over. On continued exposure, marked fatigue is shown, the e.m.f. decreasing in a few minutes to half value. By use of a monochromatic illuminator and a suitable intensity control, the e.m.f. was found to show a sharp maximum for about 1μ. The results were found to be independent of the contacts used whether Cu, Al, Fe, Sn, Ag, or water. The effect was clearly not thermoelectric and different samples showed similar results. No transmitted light effect was observed. Six other minerals were found to exhibit the effect to a greater or less extent, including molybdenite (MoS_2) and acanthite (Ag_2S). The resistance of argentite was found to vary with voltage, and, measured instantaneously, was only half as great for 20 as for 4 volts. The resistance is about 4/5 as great in the light as in the dark, the ratio being independent of voltage. The resistance also increased with time, the crystal finally reaching a state when no longer light sensitive. Recovery was slow. Experimental details are included. H. H. Ho.

637. *The Thermoelectric Effect in a Homogeneous Wire with Abrupt Change of Section.* **L. Pechinger.** [Extract from Experimental contribution to the question of the existence of Benedicks' thermoelectric asymmetric effect.] (Akad. Wiss. Wien, Ber. 131. 2a. No. 8. pp. 491–494, 1922.)—The author refers to the work of Benade [Abstract 195 (1922)] who found this effect to decrease as the mean temperature increased, thus excluding Benedicks' explanation of the phenomenon as the inverse of the Thomson effect. In the present paper the section of Fe, Ni, and constantan wires was altered by filing over a length of 9 mm. and a steep gradient of temperature produced by heating the wire on one side of the constriction. The e.m.f. is found to depend on the shape of the constricted section and with the same wire to reverse sign with the magnitude of the heating current used to produce the gradient. In the opinion of the author the effect is an ordinary thermoelectric effect due to lack of homogeneity of the inner and outer portions of the wire. L. L.

638. *The Diminution of Benedicks' Thermoelectric Effect in Vacuum.* **E. Rumpf.** (Phys. Zeits. 24. pp. 437–438, Oct. 15, 1923. Paper read before the Deut. Physikertag., Bonn, Sept., 1923.)—In the opinion of the author a possible explanation of this effect [Abstract 1369 (1917)] is the occlusion of gas in the cooler part of the conductor. It is known that Pd — Pd/H forms a thermocouple. Although quantitative experiments on the effect of occluded gas are difficult, the author finds that in the case of Cu the effect is reduced to one-half when the air pressure surrounding the wire is 2 mm. of mercury and to about one-tenth of its normal value when the pressure is 0·0002 mm. L. L.

639. *Formulæ and Tables for Calculation of Inductance of Coils of Polygonal Form.* **F. W. Grover.** (Bureau of Standards, Sci. Papers

No. 468. pp. 737–762, May, 1923.)—Single-layer coils wound on formers so that each turn encloses a regular polygon are much used in radio measurements since such coils are easy to construct, have small self-capacity, and the wire is only supported by solid dielectric at the vertices of the polygon, thus reducing dielectric losses to a minimum. The paper provides formulæ from which the inductance of coils wound on triangular, square, hexagonal or octagonal formers can be calculated. It is shown that the polygonal coil has an inductance which is nearly the same as that of a circular coil of equal number of turns and axial length, if the circular and the polygonal forms enclose the same area. The results are presented in such a way that the radius of the circular coil which has an inductance exactly equal to that of the polygonal coil can be easily found. The inductance is then calculated for this equivalent circle by the use of existing formulæ for circular coils. Tables and curves of equivalent circular coils are given to assist in the numerical computation, examples being worked out in the text. B. H.

640. *Standards of Capacity Particularly for Radio-Frequency Currents.* **J. B. Dempster** and **E. O. Hulburt.** (Inst. Radio Eng., Proc. 11. pp. 399–404, Aug., 1923.)—Describes with diagrams and measurements the construction of a standard condenser consisting of two coaxial cylinders, after a manner suggested by the late Lord Rayleigh in 1906, in order to avoid errors due to end and lead wire capacities. The total capacity is unknown, but the variation of capacity can be accurately determined by calculation. This apparatus could not be compared with standard condensers, but indirect measurements were made with undamped oscillatory circuits and confirmed the theoretical values. A method of increasing the sensitiveness of a thermocouple when used to indicate resonance of circuits, based upon increase of coupling with increased induced current and increased sharpness of the resonance curve, is described. Finally the unsuitability of standard condensers of simple geometric form (discs and spheres), due to the disturbance of the electrostatic field by the connections, is discussed. B. J. L.

641. *Multiple Range Potentiometers.* **L. Behr.** (Optical Soc. of America, J. and Rev. Sci. Inst. 7. pp. 665–669, Aug., 1923.)—The paper briefly describes the early development of the potentiometer, particularly the attempts to produce a multiple range instrument. The three-range potentiometers of Raps and of Franke and also the arrangement adopted by Leeds and Northrup are illustrated, their advantages and disadvantages being pointed out. All these instruments suffer from the defect that check against the standard cell can only be made on the high range. Two designs of double range potentiometer, suitable for thermocouple work, are described in which the check can be made on both ranges. B. H.

642. *Moving-Coil Galvanometer of Rapid Indication.* **W. J. H. Moll.** (Phys. Soc., Proc. 35. pp. 253–256, Aug., 1923.)—Although the voltage sensitivity of a galvanometer is useful, the statement of the least measurable voltage is often a matter of more practical interest as determining the precision of reading. The stability of the spot of light is often as important, in this connection, as the sensitivity. No less important is rapidity of indication, for quite apart from the saving of time in taking observations rapid indication gives less time for disturbing electrical influences to have an effect on the readings.

The paper describes a galvanometer of rapid indication and great stability and discusses fully the details of design necessary to secure these features. It is shown that the desired end can be attained by sufficient reduction of the moment of inertia of the coil. The latter is long and narrow and is made of iron-free copper wire without a former, the turns being held together by a little shellac. The mirror is supported by the coil, being merely slipped between the turns. The coil is supported above and below by centrally mounted stretched wires of silicium bronze, a material of lower electrical resistance than the usual phosphor bronze, but of similar mechanical properties. The coil moves in the field of a strong permanent magnet fitted with a magnetic shunt so that the indications can be made aperiodic for varying external resistances. The use of an electromagnet is also suggested. Photographic records of the indications of the instrument illustrate the efficacy of the design. B. H.

643. *Oscillograph Based on the Telephone.* **R. Dubois.** (J. de Physique et le Radium, 4. pp. 272–280, Aug., 1923.)—A small optical lever is actuated by a fine rod fixed to the diaphragm of a telephone. The movements of the diaphragm are registered by a beam reflected from the mirror on to a moving sheet of sensitised paper. The Baldwin telephone is the most suitable for the purpose. The details of the mountings for three types of optical lever are given. Such an instrument is suitable for the automatic reception of Morse messages. It can also be used for many purposes in place of the Duddell instrument, than which it is more sensitive. A. A. D.

644. *A New Relay.* **H. A. Thomas.** (Journ. Sci. Instruments, 1. pp. 22–26, Oct., 1923.)—A relay in which the motion of a small metallic surface with respect to the fixed oscillating coil produces a large change in the anode current, which may be used to operate any type of mechanism without the utilisation of any contacts. Application to the operation and maintenance of a standard pendulum, without contacts. A. D.

645. *Kathode-Ray Oscillograph and its Application to Measurement of Explosion Pressures, Potential Changes in Vacuum Tubes, and High-Tension Magnetos.* **D. A. Keys.** (Frank. Inst., J. 196. pp. 577–591, Nov., 1923.)—The type of kathode-ray oscillograph described in this paper supplies an instrument of great value in many investigations. In its robust form [see Abstract 1221 (1923)] it will be useful to the engineer for the measurement of very rapid potential or pressure changes of an impulsive nature. Experiments are described in which the oscillograph is used to record explosion pressures (in conjunction with the piezoelectric effect of tourmaline crystals), magneto potential curves, etc. A. B. W.

646. *Piezoelectric Crystal Resonators and Crystal Oscillators Applied to the Precision Calibration of Wavemeters.* **G. W. Pierce.** (Am. Acad., Proc. 59. pp. 81–106, Oct., 1923.)—The resonator used in the work here described was of the type previously described by Cady [Abstract 66B (1923)], but only a single triode vacuum tube was used. In the anode circuit was included a condenser of about 0·001 μfd. (across which could be connected either telephones or an audio-frequency amplifier) and a 30,000-ohm resistance. The latter could be replaced by an inductance of any large value. A grid leak was used of about 1 megohm, and the piezoelectric crystal, provided with electrodes, was connected across the anode and grid. With the quartz crystal used, oscillations were generated in the valve circuit of frequency 419,640 cycles per second. This frequency was found to be remarkably constant. Variation of temperature from 8° to 24° C., of pressure on the crystal from a small amount to 2 kgm., of filament current, anode voltage, resistance, inductance, or capacity had no effect on the oscillation frequency as great as 0·03 %. By means of this single fixed frequency and its harmonics, used in co-operation with a variable electric oscillator and its harmonics, it has been found possible to calibrate completely and by fine steps a series of wavemeters extending in range from 50 m. (6000 kilocycles per second) to 50,000 m. (6 kilocycles per second), and to obtain finally the absolute period of the crystal oscillator itself in terms of a standard clock, a tuning-fork being used as intermediary. The calibration was carried out with an accuracy of about 0·1 % over the entire range, and a number of crystal resonators were then standardised as to fundamental and partial frequencies. A. W.

647. *Temperature Coefficients of Unsaturated Weston Cells.* **W. C. Vosburgh** and **M. Eppley.** (Am. Chem. Soc., J. 45. pp. 2268–2277, Oct., 1923.)—Cells were made up with a series of solutions of cadmium sulphate. The e.m.f. increases in an approximately linear fashion as the cadmium sulphate concentration decreases. The e.m.f.'s are linear functions of the temperature between 15° and 35° C., but are not between 35° and 45° C. In the case of the solution having 43·12 % of $CdSO_4$ the e.m.f. is independent of temperature between 15° and 35° C. and has an e.m.f. of 1·01873 volts. Mercurous sulphate, prepared by reduction of mercuric sulphate with formaldehyde at 100° C., behaved in the same manner as the electrolytic salt. The differential heat of solution of hydrated cadmium sulphate is calculated, and is not in accordance with the figures given by Steinwehr. W. R. C.

648. *Measuring Very Small Currents.* **Research Staff of General Electric Co., London.** (Journ. Sci. Instruments, 1. pp. 56–59, Nov., 1923.)—The method described for measuring currents of 10^{-9} amps. or less, consists essentially of a current divider, dividing a current of variable magnitude into two very unequal fractions, i_1 and i_2, the ratio r of these functions being independent of the current. In this particular instrument the ratio is about 10,000 : 1, the smaller fraction i_2 of the two currents being used to compensate the larger fraction i_1. In an evacuated vessel is a hot tungsten wire kathode heated by a battery controlled by a rheostat. The anode is a nickel cylinder coaxial with the kathode, and consists of a central portion, terminated by nickel guard rings. The current i_1 flows between the kathode and the central anode cylinder, which is pierced by a small hole. Electrons falling on this hole pass into a Faraday cylinder and provide the current i_2, used to compensate the unknown current. Causes which are likely to produce a variation in r are (1) the presence of residual gas in the vessel; (2) the current may distort the field; (3) the field will be changed somewhat by variations in the voltage drop along the filament; (4) some part of the current through the hole may be carried by secondary electrons excited by the impact of the primaries on the anode; (5) the distribution of temperature and therefore of thermionic emission along the kathode will change with its mean temperature and with the total current. All these causes are discussed in some detail. T. C. H.

649. *A Simple Compensation Method for the Measurement of Capacity.* **W. Geyger.** (Jahrb. d. drahtl. Tele. 22. pp. 155–163, Oct., 1923.)—The method has been described by the author in the Archiv für Elektrotechnik [Abstract 329 (1924)]. In the present paper the use of a telephone receiver, instead of a vibration galvanometer, as a null instrument is mentioned; in many cases a tube voltmeter can be advantageously employed. The variation of the capacity of an electrostatic voltmeter with the deflection has been measured by means of the telephone, and in a valve tube the capacities between kathode and anode have been obtained. H. N. A.

650. *Measurement of Dielectric Losses at High Voltages by the Wien Bridge.* **A. Rosen.** (Phys. Soc., Proc. 35. pp. 235–251; Disc., 251–252, Aug., 1923.)—The author first defines the loss-angle of an imperfect condenser, and discusses the methods which have been used to measure it, especially in the case of high-voltage electric cables. The theory of the ordinary form of Wien bridge is given, in which the imperfect condenser (represented by a perfect capacitance in parallel with a resistance) is compared with a standard condenser and series resistance in the adjacent arm of the bridge. The remaining arms consist of the ratio resistances. In the usual form, with the detector connected across the ratios, the standard condenser is an air condenser built to withstand the high voltage. The author shows that by interchanging the positions of detector and source—*i.e.* connecting the source across the ratios—the drop of voltage over the standard arm can be made low, so that standard mica condensers can be used. The ratio resistances are then made to withstand the testing voltage. Earth-capacity effects at the detector branch points are eliminated by the use of the Wagner earthing device. Full practical details of the experimental arrangements are given, together with the results of tests on cable samples up to 30 kilovolts. A comparison of loss measurements made by the bridge and by the high-voltage Duddell-Mather wattmeter is added. The use of the bridge to measure the wire-to-wire and wire-to-sheath losses in multicore cables is described and the paper concludes with appendices in which the residual errors of the bridge and the theory of the earthing device are worked out. B. H.

651. *Measurement of High Values of Insulation Resistance.* **J. B. Whitehead.** (El. World, 82. pp. 1007–1009, Nov. 17, 1923.)—After briefly discussing the physical properties of insulating materials, in particular those of dielectric absorption and resistivity, the paper proceeds to describe an experimental trouble encountered in making measurements of these quantities. Using a test sample made up as a guard-ring condenser, and employing the ordinary direct deflection method with a highly sensitive galvanometer, great difficulty was found in taking the galvanometer deflection/time curves for various voltages, from which the absorption and resistivity can be deduced. When the absorption current had died out and only the small conduction current remained, the galvanometer spot became violently unsteady. This instability was finally traced to slight fluctuations in the voltage of the d.c. supply, these variations being too small to be detected by any ordinary voltage-measuring instrument. High-voltage d.c. generators were first tried, and these were replaced with very slight improvement by a hot kathode rectifying tube. Owing to cost and difficulty of maintenance, storage cells were considered out of the question. Success was finally attained by the use of a source consisting of 2000 dry cells of the type used in radio plate batteries mounted in suitable frames. The initial cost is not great, and though the life is short, the cost of replacements is not high. The battery has characteristics equalled only by the much more expensive storage battery. B. H.

652. *Dielectric Losses at Radio Frequencies in Liquid Dielectrics.* **A. B. Bryan.** (Phys. Rev. 22. pp. 399–404, Oct., 1923.)—The resistance variation method was used to measure the phase-difference ψ and the dielectric constant K for frequencies between 2×10^5 and 14×10^5 cycles per second. The liquids investigated were carefully dried nitrobenzene, distilled water, and xylene. The results for the first two were similar, and the variation of ψ with the frequency f can in both cases be represented by an equation of the form $\psi = a + b/f$, where a and b are constants. For nitrobenzene at 30° C. $a = 0 \cdot 028°$ and $b = 6 \cdot 03 \times 10^4$; for distilled water at 23·5° C. $a = 0 \cdot 8°$ and $b = 2 \cdot 09 \times 10^6$. These results indicate that in addition to true dielectric loss there is a leakage through the liquid proportional to $1/f$. For xylene, ψ was too small to measure. K was found to be practically independent of the frequency, being 2·24 for xylene, about 35·5 for nitrobenzene, and of the order of 100 for water. As regards temperature, experiments with a sample of nitrobenzene, for which ψ was 12 times as great as for a carefully dried sample, showed a decrease of the value of K from 42 at 20° to 24 at 142°, while ψ increased in the same range in the ratio of 7 to 1. [See Abstract 2264 (1923).] A. W.

653. *Measurement of Short Radio Wave-Lengths and their Use in Frequency Standardisation.* **F. W. Dunmore** and **F. H. Engel.** (Inst. Radio Eng., Proc. 11. pp. 467–478, Oct., 1923.)—The paper describes one method of establishing frequency standards employed by the Bureau of Standards. The method is based on the direct measurement, in linear measure, of the wave-length of very short standing waves on a pair of parallel wires. The wave-lengths measured were from 9 to 16 m., the corresponding frequencies being 33,000 to 19,000 kilocycles per second. The generator for these frequencies had for grid and anode coils single turns of No. 12 copper wire 18·5 cm. diam. spaced about 3 cm. apart. The valve capacities were such that a 9-m. wave was obtained with no additional capacity. The addition of a small variable air condenser connected across the grid and anode served to give a range down to 17 m. wave-length. Choke coils were introduced in all battery leads to maintain stable operation. The parallel wire system terminated in a loop which was used for coupling to the generator. A sliding thermo-galvanometer was used as indicator for the standing waves along the wires, and with a shunt across its terminals the adjustment for maximum current could be made to less than 1 mm., giving an accuracy of at least 1 in 5000. A description is next given of a method for calibrating a wavemeter at frequencies from 30,000 to 352 kilocycles (10 to 850 m.). This method makes use of the harmonics in a second radio-frequency set, one of which, when combined with the output from the short-wave generating set, produces a beat note in a receiving set tuned to the short-wave frequency. Exact setting is indicated by the disappearance of the beat note. Knowing the frequency of the short-wave set from the parallel wire measurements, and the order of the different harmonics used in the second generating set, the frequency of the latter may be determined within the above limits. The wavemeter standardised in these measurements was the standard wavemeter of the Bureau of Standards. The results agreed with two other calibrations by different methods within 0·2 %. A. W.

654. *Amplification of the Current of Photoelectric Cells and its Applications.* **G. Ferrié, R. Jouaust** and **R. Mesny.** (Comptes Rendus, 177. pp. 847–849, Nov. 5, 1923.)—The instantaneous manner in which photoelectric cells respond to the light with which they are illuminated makes them valuable for studying certain rapid movements. Unfortunately the photoelectric currents are excessively weak. In this paper an account is given of two methods of employing tubes with three electrodes as relays without inertia to amplify these minute currents. To obtain the best results it is found that the capacity of the grid with respect to the different parts of the lamp must be small and that the grid must be well insulated. With a lamp having the dimension of an ordinary lamp used for reception, an amplification of 1000 has been obtained by one of the methods described. By the second method in which between the cell and the lighting source a disc furnished with slits is made to rotate with a high velocity. With this second arrangement an amplification of the order of 10^6 has been obtained, and it would appear possible by this means to determine periods of oscillation of the order of 1/1000 sec. about. A. E. G.

ALTERNATING CURRENTS AND MAGNETISM.

655. *The Theory of the Generation of Alternating Currents by Means of Triodes.* **N. Shuttleworth.** (Inst. El. Eng., J. 61. pp. 1121–1133, Oct., 1923.)—On the assumption of straight line characteristics of a valve, the equations for its operation as oscillator with magnetic coupling between grid and anode circuits (with the " anode tap " arrangement) are written down and steady state solutions obtained giving the frequency of the oscillations and the mutual inductance necessary for their maintenance. A study of the relation between output and efficiency follows, and some experimental results confirm the conclusions reached. Finally a graphical presentation of the oscillating conditions is given. E. M.

656. *Eddy-Current Losses in Massive Iron.* **A. Lang.** (Elek. u. Maschinenbau, 41. pp. 621–624, Oct. 28, 1923.)—A mathematical investigation of the eddy-current losses in massive iron when subjected to an alternating field. The cases dealt with are: (1) A plate, limited in the x direction, unlimited in the y, z, directions—field parallel to the y axis. (2) A cylinder of infinite length, field parallel to the axis. Each case under conditions (a) μ = constant, (b) B = constant. L. L.

657. *The Torques and Forces between Short Cylindrical Coils Carrying Alternating Currents of Radio Frequency.* **W. A. Parlin.** (Phys. Rev. 22. pp. 193–197, Aug., 1923.)—Measurements were made of the forces between two short cylindrical coils carrying alternating currents of frequency 60 to $1\cdot5 \times 10^6$ cycles.—(1) *Coils with a common diameter,* mounted like a dynamometer, the outer coil being suspended and free to turn about the fixed inner one, were connected in series with the current in the same sense for zero angle. The torque was found proportional to the square of the current for all frequencies, but for a constant angle began to increase with the frequency at 3×10^5 cycles. The ratio of the torque for 15×10^5 cycles to that at 3×10^5 cycles decreased from two at 10° to one for 90° and remained one for all angles for which the currents were in opposite sense. In the case of 60 cycles, the variation of the torque with angle corresponded roughly with that computed from Maxwell's equations. (2) *Coils with planes parallel* showed a similar increase of force with frequency for frequencies above 3×10^5 cycles, when the currents were in the same sense, but not when they were in opposite sense. It is suggested that these variations with frequency may be due to the reactions caused by the radiation of energy from the coils in the form of electromagnetic waves. AUTHOR.

658. *Kennelly's Theorem of Constant Ratio of Mean to Mid Potential or Current.* **A. E. Kennelly.** (Nat. Acad. Sci., Proc. 9. pp. 215–221, July, 1923.)—*Statement of the Theorem.*—Let the points 1, 2, 3, . . . be situated at equal intervals along a uniform electrical conductor which is steadily carrying an alternating current of any single frequency. For zero frequency the current becomes a steady continuous one. Let the angular distance between any adjacent point pair be θ hyperbolic radians, where θ is, in general, a complex hyperbolic angle; except in the continuous-current case, where θ reduces ordinarily to a real hyperbolic angle. Let E_1, E_2, E_3, . . . be the respective r.m.s. potentials of the points, with respect to ground or neutral, expressed in vector volts. Similarly, let I_1, I_2, I_3, . . . be the respective alternating r.m.s. currents in the line at these points, expressed in vector amperes. Then $(E_1 + E_3)/2$ is the vector mean potential of the points 1 and 3 and E_2 is their mid potential, and their ratio is $(E_1 + E_3)/2E_2 = \cosh\theta$. Similarly for the corresponding currents, $(I_1 + I_3)/2I_2 = \cosh\theta$. That is to say, the mean-to-mid ratio of potentials or currents for any two points 1 and 3, angularly distant from each other by 2θ hyperbolic radians is always the same along the uniform line, so long as the frequency remains constant, and is equal to $\cosh\theta$, a complex or plane-vector numeric in the general case. This is Kennelly's theorem. *Proof.*—The proof is very simply obtained by showing it to be a direct consequence of the known results that on any uniform real or artificial line in the steady state, carrying single-frequency alternating currents, the potential and the current at any point are proportional, respectively to the sinh and cosh of the position angle of the point. The author stated and proved the theorem under very restricted conditions in his book, "Artificial Lines for Continuous Currents in the Steady State," 1917, p. 38. The theorem also applies to all tables of $\sinh\theta$, $\cosh\theta$, and $\epsilon^{\pm\theta}$ whether θ be real, imaginary, or complex, where, as ordinarily occurs, the values of θ increase in uniform arithmetical progression. Examples of the application of the theorem are given. G. W. DE T.

659. *Motion of Rotatable Coil Carrying Alternating Current in Radial Homogeneous Magnetic Field.* **C. Weisglass.** (Zeits. techn. Physik, 4. 12. pp. 473–476, 1923.)—A mathematical investigation that such a coil may, under determinable conditions, give a ballistic deflection or one proportional to the current. This does not, however, mean that such an arrangement could be employed for the measurement of alternating currents; for, in the first place, the deflection at any moment depends on the phase at the moment, and if this and other technical difficulties were overcome, another difficulty would remain in the fact that the predominance of the principal, or proper motion, does not coincide with the equilibrium position. G. W. de T.

660. *Magnetostriction and Magnetoelectric Effects in Iron, Nickel, and Cobalt.* **P. McCorkle.** (Phys. Rev. 22. pp. 271–278, Sept., 1923.)—Pure annealed wires of the three metals were tested for the Wiedemann, Joule, thermoelectric and resistance effects. The method of measuring the Wiedemann effect was that of Pidgeon [see Abstract 642 (1919)], and in the case of Armco iron the negative twist did not disappear, as found by Pidgeon, but continued to increase negatively even in the highest fields used (2500 gauss). The results for cobalt found by Pidgeon were confirmed, and in all four effects this metal occupies a position intermediate between iron and nickel. In the Joule effect in cobalt there was a continual decrease in length, but no maximum of decrease was observed. In the change of thermal electromotive force in a longitudinal magnetic field, $\Delta E/E$ was positive for iron, negative for nickel, and cobalt lay between, $\Delta E/E$ being first positive and then negative above 300 gauss. In the change of resistance in a longitudinal field, $\Delta R/R$ becomes constant for iron at 2×10^{-3} for $H > 800$ gauss, and for nickel at $14 \cdot 8 \times 10^{-3}$ for $H > 400$ gauss; in cobalt $\Delta R/R$ increases steadily to 4×10^{-3} at 1000 gauss [see also Abstract 413 (1917)]. Heaps' results [Abstract 1333 (1915)] were not confirmed. G. E. A.

661. *Magnetic Moments of Rotation and Magnetic Molecular Orientation.* **R. Lucas.** (Comptes Rendus, 177. pp. 950–952, Nov. 12, 1923.)—Langevin has showed that the rotation of a molecule is able to carry the electrons with it, and also the magnetic axis of the molecule, which is only slightly deformed by the thermal agitation. A body in rotation will appear, to fixed observers, to be polarised magnetically, the intensity of polarisation varying with the angular velocity; $I = -2\chi\omega m/e$, in which I = magnetic polarisation, χ = diamagnetic susceptibility, ω = angular velocity, m = mass of electron, e = charge of electron. The effect is too small to be measured experimentally, but becomes important in connection with molecular rotations. A molecule of HCl, for example, at ordinary temperature, has a mean angular velocity of the order of 10^{13}; thus the couples due to the action of a magnetic field on the magnetic moments of rotation will be greater, in general, than those due to the effects of the polarisation caused by the field; and these actions should be taken into account in considering the magnetic molecular orientation, and the phenomena which depend on it, susceptibility (diamagnetic) and magnetic double refraction, as Cotton and Mouton, and Langevin have shown. The author has found that the magnetic orientation depends both on the magnetic anisotropy and the inertial anisotropy; a number of molecules which are magnetically isotropic can show the phenomena of molecular orientation if they have inertial anisotropy. A study of this orientation in a particular case does not modify Langevin's law of the relation to temperature and field. H. N. A.

662. *Experiments on the Electric Dissymmetry of Iron Molecules.* **A. Perrier** and **A. J. Staring.** (Arch. des Sciences, 5. pp. 333–360, Sept.–Oct., 1923.)—The experimental problem discussed in the present paper is that an electric field acting on matter may produce the appearance of magnetic polarisation in the same direction and generally may modify a pre-existing magnetisation. Previous work by Perrier is referred to [see Abstract 762 (1923)]. The present experiments attempt in particular the realisation of the following conditions: (1) Separation of certain effects of the magnetic field due to the current from those of the electric field by means of symmetry processes. (2) Reduction to a practical minimum of the intensity of the parasitic magnetic field by a current distribution in alternate thin layers. The experiments have only been conducted upon iron but have led to certain positive qualitative results. Experimental details are given at length with tables and graphs. It follows from the data that an electric current, or the field which maintains it, excites or modifies the magnetisation of the iron through which it travels, in a manner longitudinal with respect to the electric field and in the reverse sense. This would indicate that the iron molecules possessed an electric moment of opposite sense to their magnetic moment.

H. H. Ho.

663. *Effect of Crystal Structure on Magnetostriction.* **C. W. Heaps.** (Phys. Rev. 22. pp. 486–501, Nov., 1923.)—When a bar of iron is placed with its length parallel with a continually increasing magnetic field, numerous experiments have shown that the bar first grows longer, then contracts to its original length, and with increasing field continues to contract. Rhoades has found that the fibrous structure of the specimen exerts a marked influence on its magnetostriction, while heat treatment and crystal structure are of considerable importance. The complicated behaviour of iron suggests that the ordinary magnetostriction curve may be considered as the resultant of two curves, obtained respectively when the field is parallel to certain crystallographic axes. Experimental arrangements for the measurement of small changes in dimensions of spherical specimens are given, and enable a magnification of 405,700 to be obtained.

Magnetostriction of steel, soft iron and magnetite was investigated, using a Weiss electromagnet to produce the field, whose strength was varied up to 10,000 to 20,000 gauss, depending on the specimen and its dimensions. Curves are given showing the behaviour of a steel sphere, both before and after annealing, the changes in the second case being much greater. A sphere of soft Norwegian iron gave larger effects than the steel sphere, effects which varied with the orientation of the sphere in the field. It is interesting to note that according to the curves the volume of the sphere at first diminishes and then increases with the increasing induction. The maximum longitudinal expansions and transverse contractions are of the same order of magnitude. The induction appears to be independent of the direction of the field.

A soft iron disc, part of a single grain formed in a plate of iron with 3½ per cent. Si, showed larger dimension changes than have yet been found in iron. Along different diameters of the disc quite different results are obtained; in some cases there was a contraction, in others an expansion. Preliminary work with a magnetite sphere indicated a lack of cubic symmetry for both transverse and longitudinal effects. Changing the direction of the field with respect to the crystal axes may change the magnetostriction in a given direction from a contraction to an expansion. The transverse magnetostriction changes in a similar manner.

Theories are briefly discussed. As above, the observed curve is the resultant of two superimposed effects, and the Villari reversal probably a consequence of heterogeneous crystal arrangement in the iron. Ewing's latest model of the iron atom seems to be capable of explaining the various magnetostrictive effects. [Smith, Abstract 321 (1924).] W. V. M.

664. *The Change of Thermoelectric Force of Iron, Nickel, and Cobalt with Time, after Drawing and Magnetisation.* **J. Thiele.** (Ann. d. Physik, 72. 7. pp. 549–564, Nov., 1923.)—Borelius has studied the effect of drawing, rolling, etc., on the thermoelectric forces of certain metals [Abstract 258 (1920)], and in the case of Fe and Ni found that the magnitude of the effect changed with time. He concluded from his investigations that the effect was dependent on the surface conditions of the metals. It could be overcome by heating. Other possible explanations suggested by the present author are occlusion of gases or the fact that the wires used were magnetic or became magnetised during the mechanical treatment to which they were subjected. To elucidate this he has repeated the work of Borelius, using essentially the same experimental arrangements and commencing with all couple elements unmagnetised. In the case of the metals Cu, Al, and Ag his results agree with those of Borelius, the magnitude of the change being unaffected by time. With regard to the metals Fe and Ni, annealing either in air, vacuum, atmospheres of N or of H has no influence on the time change of electromotive force, consequently the explanation is not due to gas absorption. With drawn samples of these materials (Fe and Ni) Borelius found in the case of iron a continuous increase in the magnitude of the effect extending over a long period of time (100 hrs.) and in the case of Ni a diminution over the same time period. The author, on the contrary, finds a diminution for Fe and an increase for Ni, but the time periods are shorter (1½ hrs.), constant values then obtaining. When the wires are magnetised then changes in the effect may be observed over much longer periods of time. The sign of the change, however, depends on whether the magnetised or unmagnetised element is annealed, and the magnitude of the effect depends on the degree of magnetisation but not on its direction. Cobalt shows a similar behaviour. Since the wires used by Borelius showed changes extending over long periods of time, the author concludes that these wires must have been magnetised. L. L.

665. *Paramagnetism at Low Temperatures.* **L. C. Jackson.** (Roy. Soc., Phil. Trans. 224. pp. 1–48, Nov. 21, 1923. Comm. No. 163 from the Phys. Lab., Leiden.)—An expansion of two previous papers [see Abstracts 1988 and 1989 (1923)]. The suggestion was made by Onnes and Oosterhuis that the constant Δ in the equation $\chi(T + \Delta) = \text{constant}$ is related in a simple manner to the distances between the paramagnetic atoms in a solid, Δ being greater the smaller the distance between the atoms in question. The author makes a hypothesis as to the space lattice for the nickel atoms in nickel sulphate heptahydrate. The space lattice has been tested by the Debye-Scherrer method of X-ray analysis, and the X-ray photograph obtained is found to be in agreement with the suggested structure. G. E. A.

666. *Demagnetising Factors of Cylindrical Rods.* **J. Würschmidt.** (Zeits. f. Physik, 19. 5–6. pp. 388–397, 1923.)—This paper deals with a determination of the demagnetising factors of cylindrical rods by a ballistic method. The factors determined here are smaller than those obatined by Mann using the magnetometer method and by Dubois using the ballistic method. They agree, however, with the ballistic results of Shuddemagen. The demagnetising factor is shown to be independent of the composition of the rod for the range of field strengths used—up to about 4 c.g.s. units. A. A. D.

667. *Measurement of Magnetic Fields by a Magnetron.* **A. W. Hull.** (Phys. Rev. 22. pp. 279–292, Sept., 1923.)—The magnetron is a symmetrical thermionic valve in which the kathode is a straight filament and the anode a concentric cylinder [see Abstract 1142B (1921)]. The effect of applying a magnetic field parallel to the kathode is to cause the electrons, at a certain critical voltage or field intensity, to miss the cylinder, and the current to the anode falls abruptly to zero. The critical value H_0 of magnetic field just sufficient to prevent electrons from reaching the cylinder is given by $H_0 = 6\cdot72V^{1/2}/R$, where V is the p.d. in volts between anode and kathode and R the radius of the cylinder in cms. The circuit and mode of working the tube are fully described; the ordinary tube has a field-measuring range of about from 20 to 500 gauss. The magnetron may also be employed for measuring weak fields by supplying the ineffective part of the field by means of a constant current in a solenoid enclosing the valve. A device employed for producing a current in the coil proportional to $V^{1/2}$ is a standard gas-filled tungsten lamp in series with coil and filament. The second method can be used for measuring fields lying between 0·01 and 100 gauss, and the accuracies attainable by the two methods are respectively ½ and 1 per cent. G. E. A.

668. *Trial of a Coil without Iron, Giving Intense Magnetic Fields. Application to the Study of the Magnetic Saturation of Iron.* **R. Fortrat** and **P. Dejean.** (Comptes Rendus, 177. pp. 627–630, Oct. 8, 1923.)—The apparatus described is designed to produce intense magnetic fields by the direct action of strong electric currents. The interior of the coil contains a free cylindrical space of 34 mm. diameter. The windings consist of only 8 concentric layers of coarse wire of electrolytic copper of rectangular section, with spaces between them for brisk circulation of water. A current up to 4740 amps. was used, absorbing 277 kilowatts. The magnetic field was measured by induction, using a coil 30 mm. in diameter and a fluxmeter. With a current of 3530 amperes a field of 41,200 gauss was produced, the p.d. at the ends of the coil being then 51·8 volts. A measurement of the field was also made by the method of *dénivellation*, a change of level of the liquid (water placed in an atmosphere of hydrogen) of 7·07 mm. being obtained with a current 3790 amps. This corresponds to a magnetic field of 43,900 gauss, and agrees well with the induction method. The apparatus has also been utilised for the measurement of intensity of magnetisation of iron. An ellipsoid of revolution of iron being placed in the centre of the coil, the intensity of magnetisation in a field of 1140 gauss was I = 1700; with a field of 23,500 gauss I = 1710, and with 38,950 gauss I = 1720. These figures illustrate the extreme slowness with which iron becomes saturated in intense magnetic fields. T. B.

669. *The Magnetic Character of the Year* 1922. **G. van Dijk.** (Terrest. Magn. 28. p. 82, Sept., 1923.)

670. *Origin of the Earth's Magnetic Field.* **H. A. Wilson.** (Roy. Soc., Proc. 104. pp. 451–455, Nov. 1, 1923.)—If the two kinds of electricity in matter are not exactly balanced, small residual effects of magnetic or gravitational action are probable, and moving matter might be expected to produce a magnetic field in proportion to its gravitational action. The assumption that a gravitational unit of mass is equivalent to an electrostatic unit of electricity leads to magnetic fields, for the earth and sun, of the right order of magnitude. An experiment made to test this theory shows, however, that not more than one part in a thousand of the earth's magnetic field can be attributed to a magnetic effect of moving matter similar to that of moving electricity. If the earth's magnetic field is to be explained by a slight modification of the laws of electrodynamics, the field may be due to the rotation, but not the translation, of matter; also it is probable that purely angular motion is insufficient in itself. [See also Abstracts 1585 (1912) and 1331 (1923).] G. E. A.

671. *Magnetic Phenomena in the Antarctic.* **C. Chree.** (Roy. Soc., Proc. 104. pp. 165–191, Sept. 1, 1923.)—The paper discusses the synchronous observations at Cape Evans and Adelie Land, between which the south Magnetic Pole lies. The diagrams of diurnal range of all the components measured are given. Further, the daily characters are worked out on the system suggested at the meeting of the International Geophysics and Geodetic Union, 1922. The sensitiveness of the Antarctic (and presumably of the Arctic also) diurnal inequalities implies a delicate indication of general magnetic disturbance. The observations correspond to a sun-spot minimum. Observations at a maximum are very desirable, so also is a synchronous investigation in both the Arctic and the Antarctic. W. A. R.

RADIOGRAPHY AND ELECTROPHYSIOLOGY.

672. *The Use of Heavy Gases in X-Ray Diagnosis.* **R. Ledoux-Lebard, A. Lepape** and **A. Dauvillier.** (Comptes Rendus, 177. pp. 952–953, Nov. 12, 1923.)—Heavy gases, such as methyl haloids, rare gases, etc., could be used to produce pneumo-peritoneum, pneumo-kidney, etc., for purposes of X-ray diagnosis. The former group of gases produce toxic and irritative effects, and are restricted to purely physical measurements. The group of rare gases can possibly be used in biology, and possibly in diagnosis in the human subject. The difficulty of production of these rare gases is pointed out, but the authors showed to the Academy an example of a radiograph of a knee in which krypton was injected, and they consider the employment of this gas in the human subject is indicated. B. J. L.

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

673. *Further Determinations of the Constitution of the Elements by the Method of Accelerated Anode Rays.* **F. W. Aston.** (Nature, 112. pp. 449–450, Sept. 22, 1923. Paper read before the British Assoc., Liverpool, Sept., 1923.)—The following results have been obtained mainly by using the fluorides:

Element.	Atomic Number.	Atomic Weight.	Minimum Number of Isotopes.	Mass Numbers in Order of Intensity.
Sc	21	45·1	1	45
Ti	22	48·1	1	48
V	23	51·0	1	51
Cr	24	52·0	1	52
Mn	25	54·93	1	55
Co	27	58.97	1	59
Cn	29	63·57	2	63, 65
Ga	31	69·72	2	69, 71
Ge	32	72·5	3	74, 72, 70
Sr	38	87·63	1	88
Y	39	88·9	1	89
Ag	47	107·88	2	107, 109

Hafnium, niobium, molybdenum, cadmium, barium, and lead gave no results. The hafnium sample contained about 50 % of zirconium, and an extremely faint effect at 90 obtained with this and with pure zirconium salts suggest that this is the principal isotope of this element. The mass numbers were usually determined with reference to the lines of iron or iodine, and no outstanding divergence from the whole number rule was observed. H. N. A.

674. *Distance-Effect of Chemical Affinity.* **T. W. Richards** and **W. T. Richards.** (Nat. Acad. Sci., Proc. 9. pp. 379–382, Nov., 1923.)—Preliminary attempt to measure this gravimetrically. In no case was any attracting tendency observed capable of balancing as much as 0·1 mg. on the opposite arm. The force of chemical affinity must decrease very rapidly as the distance between the attracting atoms increases. A. D.

675. *The Law of Definite Proportions in the Light of Modern Research.* **U. R. Evans.** (Faraday Soc., Trans. 19. pp. 420–429; Disc., 429–432, Nov., 1923.)—The melting-point diagram for binary alloys frequently shows a maximum at a composition represented by a simple atomic formula, which is taken to indicate the formation of a compound. The author claims that the same considerations should apply to points where maximum hardness or an abrupt change in chemical behaviour are exhibited, as this usually occurs at a simple atomic composition. A compound should be regarded merely as the most stable of a continuous series of solid solutions. The author's views receive support from the fact that oxides of metals frequently occur as homogeneous bodies of variable oxygen content, *e.g.* Fe, Pt, Ni. Some chlorides and sulphides exhibit similar characteristics. This appears to question the universal applicability of the law of definite proportions.

In an appendix the cause of maximum hardness of metallic mixed crystals at equi-atomic composition is discussed. The definite meaning of the maximum melting-point and the methods of testing hardness are considered in the discussion. B. W. C.

676. *Separation of Gas Mixtures by Diffusion into a Stream of Another Gas.* **G. Hertz.** (Zeits. f. Physik, 19. 1. pp. 35–42, 1923.)—A stream of water-vapour is passed along a tube the end of which is closed by a metal plate bored with a series of small holes. This end is sealed into the vessel containing the mixture of gases to be separated—in this case helium and neon. The gases diffuse through the holes against the water-vapour stream—the lighter gas the more readily. By suitable arrangements the backward diffusing component can be drawn off and freed from water-vapour. In this way spectroscopically pure helium was obtained from a mixture containing 30 % of this gas. A second arrangement, based on the same principle, is described. Finally, the separation of gaseous isotopes by these methods is discussed, the author concluding that with the present types of apparatus the experimental difficulties are too great. A. A. D.

677. *Theory of Colour Production.* **J. Stieglitz.** (Nat. Acad. Sci., Proc. 9. pp. 303–312, Sept., 1923.)—Starting from the fact that all organic dyes become colourless on reduction to the leuco-compound, which gives the colouring matter again on oxidation, the author points out that, fundamentally, oxidation consists in the removal of electrons from an atom and results in the conferment on the oxidised atom of oxidising power, this enabling it to attract electrons and, by absorbing the lost electrons, to undergo reduction. As regards indophenol, a typical organic dye, the colour is regarded as due to the combination within a single molecule of a strong positive oxidising atom (in the quinonoid or chromophoric group of the structural theory of colour) with a strong negative reducing atom (in the hydroquinonoid group containing the auxochrome of the old theory), and maximum colour depth and intensity are developed by the increase of the reducing power to a maximum with the aid of a strong base. This combination produces colour by the absorption of a part of the white light through the vibrations of the reducing electrons which are largely freed from intra-atomic restraints. Further, the fact that basic dyes such as pararosaniline develop their maximum of colour depth and intensity when combined with acids is regarded as related to the pronounced intensification of the oxidising power of many oxidising agents produced by acids. Evidence indicating that the vibrations of electrons in the dyes are intra-atomic and not due to any transference between the two carbon atoms of the quinonoid and hydroquinonoid nucleus has been adduced by the author in connection with the characteristic purple dye murexide (Am. Chem. J. 36. p. 661, 1904).

Confirmation of the views developed above for the organic dyes is found in the inorganic field. Apart from colours produced by loosely held electrons in atoms with an odd number of valence electrons and in such atoms as those of metallic elements, colour in inorganic compounds may be ascribed partly to intra-atomic and partly to inter-atomic (intra-

molecular) oxidation—reduction potentials of sufficient force to render possible vibrations of electrons in the reducing component long enough to absorb visible light waves and show their complementary colours. The salts and oxides of ions of elements with weakest oxidising power of the positive component are uniformly colourless, unless a coloured kation or anion is present. On the other hand, combination of a strong oxidising kation with a strong reducing anion leads to strong colour development, as in the black platinic iodide. Again in series like AgCl, AgBr, AgI; ZnO, CdO, HgO; and ZnS, CdS, HgS, colour depth evidently goes along with inter-atomic oxidation-reduction potentials. Various other examples are quoted in support of the theory advanced above.
T. H. P.

678. *The Discontinuity of the Hydration Process.* **W. A. Davis** and **J. V. Eyre.** (Roy. Soc., Proc. 104. pp. 512–537, Nov. 1, 1923.)—Measurements are made of the percentage of moisture taken up during different periods of time by various forms of cellulose and other substances. The curves for the different materials in which the percentage of moisture gained is plotted against time intervals show a striking resemblance to each other, and, for the most part are composed of a succession of parabolic sweeps with occasional straight portions. Similar measurements made with salts, such as copper sulphate and calcium sulphate, also show frequent discontinuities. With copper sulphate the striking feature is that instead of a succession of linear parabolic curves, the graph takes the form of a series of linear portions, with relatively very short parabolic sweeps. The hydration of calcium sulphate takes place very slowly in the later stages, and the segments form very long stretches extending over many hours, which enables the exact course to be closely studied. Cellulosic materials are characterised by the almost complete absence of linear portions of the hydration curve. An entirely different hydration curve is given in an atmosphere saturated with water-vapour from that obtained when the same substance is exposed to an atmosphere of 88 % relative humidity; in some cases hydration may proceed at a slower rate over a long period of time in the atmosphere of greater humidity. A mathematical analysis of the curves produced shows that the parabolic segments can all be represented by an equation of the type $x = Bt - Ct^2$, where x is the percentage of water lost or acquired in the time t. In the linear segments the coefficient C is zero. In successive parabolic segments the values of B and C are related so as to form a simple series. It is found that practically all the successive parabolic segments pass through the origin of the coordinate system, so that the progress of action from beginning to end can be accurately calculated in terms of time reckoned from the moment at which hydration begins.
J. N. P.

679. *Calculation of the Atomic Weights of Isotopes.* **A. S. Russell.** (Nature, 112. pp. 588–589, Oct. 20, 1923.)—Simple rules, formulated from radio-active data, for the calculation of the atomic weights of the principal isotopes of both common and radio-active elements, as described in an earlier paper [see Abstract 285 (1924)], having been subsequently well confirmed by the results obtained by Aston, a brief description of the arguments by which these rules are obtained is given. The main supposition is that there are four separate radio-active series, the members of which have atomic weights given respectively by $4n + 3$, $4n + 2$, $4n + 1$, and $4n$, where n is an integer, the first of these being supposed to be the actinium series, the second the uranium series, the third a hypothetical series the end products of which may be Bi and Tl, and the fourth the thorium series. It is probable that isotopes do not differ by more than 8 units of atomic weight. All elements are limited to two isotopes of odd atomic weight, and these differ by 2 units of atomic weight only. Elements of odd atomic number have odd isotopes only, and, if there be two, the lighter is likely to be the more stable. Even elements may have both even and odd isotopes, and an even element has always one isotope a unit of atomic weight higher than one of the isotopes of the element next below it. A large number of specific cases are given and compared with Aston's results. A. B. C. L.

680. *The Explosive Limits of Mixtures of Gases.* **E. Asch.** (Zeits. techn. Physik, 4. 12. pp. 468–471, 1923.)—In connection with the possible use of mixtures of hydrogen or methane with air and carbon dioxide as cooling agents in electrical plant, the author has determined the explosive limits of composition of such mixtures fired by an electrically heated wire. The results indicate that with the apparatus employed, the percentage of air present in explosive mixtures of hydrogen, carbon dioxide, and air ranges from about 30 % to 90 %, whilst the corresponding percentages in the case of methane-carbon dioxide-air mixtures are 80 % to 90 %. In the former case, the possibility of an explosion occurring is absent (whatever percentage of air be present) only when the carbon dioxide is present at least to the extent of 92 % of the total volume of hydrogen and carbon dioxide, whilst the corresponding percentage in the case of methane-carbon dioxide-air mixtures is 63 %. Theoretical considerations based upon Falk's determinations of the ignition temperatures of mixtures of hydrogen and oxygen (Ann. d. Physik, 1907. 24. 450) indicate that the ignition temperature of the hydrogen-air-carbon dioxide mixtures is 1133·9° abs., and that the limits of composition of explosive mixtures of these gases are given by

$$787[1 + \{(1 - a)/2(1 + a)\}^2 + \{(1 - a)/2(1 + a)\}^3] \\ + (30a\gamma + 25\beta)/(30\gamma + 25\beta/a) = 1133\cdot 9,$$

where $a = O_2/H_2$; $\beta = CO_2/H_2$; $\gamma = N_2/O_2$. J. S. G. T.

681. *The Cold Formation of Crystalline Bodies.* **E. Siebel.** (Zeits. f. Physik, 20. 1. pp. 45–53, 1923.)—The laws operating during the cold solidification of crystalline bodies have been mathematically formulated on the assumption that crystals oppose a minimum resistance along certain gliding planes to an imposed displacement, which resistance is independent of external forces. In consequence a distortion occurs which can be measured. The mathematical procedure adopted has been to establish the connection between the normal forces necessary for the production of an alteration in form and the angle of inclination of slipping plane, and a discussion is given of the relation between the shape and the distortion forces. The laws so established were confirmed by means of experimental curves and are expressed in logarithmic form.

H. H. Ho.

682. *Photographic Chemistry of Gelatin.* **S. E. Sheppard, F. A. Elliott, S. S. Sweet.** (Eastman Kodak Co. Research Lab. Comm.

No. 177. Faraday Soc., Trans. 19. pp. 261–269, Nov., 1923.)—The chief points here considered are: gelatin protective action; physical chemistry of the jelly; anisotropy of swelling; the velocity of swelling. Diagrams showing the swelling in various media are given. A. E. G.

683. *Formation of Anomalous Liesegang Bands.* **F. G. Tryhorn** and **S. C. Blacktin.** (Faraday Soc., Trans. 19. pp. 433–441; Disc., 442–443, Nov., 1923.)—Two examples of the production of anomalous Liesegang bands are cited in addition to the case of lead chromate in agar gels first noticed by Hatschek. It is further shown that the substances formed in these three reactions crystallise from the respective gels more readily in the light than in the dark. Such an effect is sufficient to explain the formation of anomalous bands in these instances, and a tentative suggestion of the mechanism of the process is advanced. A. A. D.

684. *Action of Ammonium Chloride on Zinc.* **C. Drucker.** (Zeits. Elektrochem. 29. pp. 412–415, Sept., 1923. Paper read before the Deut. Bunsen. Gesell. Hanover, 1923.)—Test pieces of pure zinc, commercial zinc, and specially prepared alloys are immersed in a bath of sal-ammoniac and the loss in weight determined. Traces of iron in the zinc or the solution produce serious effects owing to electrolytic action. The effect of cadmium is due to its influence on the structure of the metal. The effect of lead, which is a minimum at concentrations of about 1 per cent., is partly electro-chemical and partly due to its influence on the structure of the metal. This is confirmed by the fact that any treatment of the metal which tends to alter the structure will increase the rate of attack. Small impurities in the sal-ammoniac increase the corrosion, especially in strong solutions. With the pure salt solutions, the attack is slowest with the stronger concentrations, which is probably due to the protective action of the reaction products. The author advocates the use of sal-ammoniac free from iron, and re-distilled zinc in the preparation of primary cells. B. W. C.

685. *The Nature of Undissociated Acids.* **H. v. Halban.** (Zeits. Elektrochem. 29. pp. 434–444, Sept., 1923.)—The author has undertaken a critical survey of the evidence upon which A. Hantzsch bases his theory of acids and electrolytes [see Abstract 2329 (1923)]. The optical evidence consists of determinations of the absorption spectra in various media; usually by the Hartley-Baly method which does not permit accurate measurement of small variations. Variations in spectra can only be ascribed to change in chemical constitution if their magnitude exceeds the variations consequent on the experimental conditions. Only non-electrolytes can be used as solvents, and the evidence of Hantzsch in this respect is considered as insufficient. The effect of dissociation on the absorption is discussed and it is concluded that Hantzsch's assumptions are unnecessary to explain the observed facts. The absorptive power of di-nitromethane and the effect of adding sulphuric acid, quoted by Hantzsch as evidence in support of his theory, is concerned in reality with the relative absorption of the anion and undissociated molecule. In the case of the chloro-derivatives of acetic acid, the absorption follows the order salt—acid—ester: this order is essential for the possibility of Hantzsch's theory being the true one. Yet with the thio-carbonic acids, the absorption of the ester lies between that of the salt and the acid, which cannot be explained by any equilibrium based on Hantzsch's ideas. Various observations upon the influence of the solvent also lead to contradictory conclusions. The explanation put forward by Hantzsch of the effect of acid on the decomposition of diazo-acetic ester is shown to be based on false assumptions, and neglects the influence of the solvent. This is confirmed by experiments with xanthogenic acids. Although a parallel exists between the strength of acids in aqueous solution, the rate of decomposition of diazoacetic ester and the position of equilibrium between an acid and indicator bases, yet this is not quantitive in nature and many exceptions to it exist, and the existence of pseudo acids is not necessary to account for the experimental facts. Hantzsch assumes that two forms of undissociated molecules exist in equilibrium in the case of weak acids, which can be expressed by chemical formulæ. This can neither be proved nor disproved experimentally, but it is not admissible to assume that every variation in the properties of a body can be expressed by a chemical formula, except in well-defined cases. The assumption of a second form of undissociated molecules appears therefore to be superfluous. As a result of these and other investigations of which space forbids the description, the author concludes that the theory of pseudo acids put forward by Hantzsch cannot reasonably be applied to acids and electrolytes in general. B. W. C.

686. *Thermodynamics of the Formation of Mixed Crystals.* **H. G. Grimm** and **K. F. Herzfeld.** (Zeits. Electrochem. 29. pp. 519–520, Nov., 1923. Paper read before the Deut. Bunsen. Gesell. Hanover, 1923.) —The case considered is that of NaCl + KCl or KCl + KBr, where one ion is common to both salts. The first important result is that the mixing is an endothermic process, so that every mixed crystal should tend to separate with falling temperature. The energy difference is of the order of 0·5 kg. cal. on heats of crystallisation of about 180 kg. cal.; but, whereas theory suggests small energy-changes when the lattice-constants of the two salts are nearly equal, this factor makes little difference to the experimental results. T. M. L.

687. *Formation of "Liquid Crystals" in Mixtures of Cholesterol and Cetyl Alcohol.* **A. Mlodziejowski.** (Zeits. f. Physik, 20. 5. pp. 317–342, 1923.)—Cholesterol on solidification gives two solid forms, with a transition-temperature of 43°; cetyl alcohol solidifies to an amorphous solid. Mixtures of these two alcohols give liquid crystals. With the help of a crystallisation microscope an approximate equilibrium-diagram has been plotted, and the conclusion is drawn that the liquid crystals represent a molecular-compound of the two alcohols, probably in equimolecular proportions. T. M. L.

688. *Kinematics of Eutectic Crystallisation.* **A. Johnsen.** (Preuss. Akad. Wiss. Berlin, Ber. 24. pp. 208–210, 1923.)—Steno suggested that a mineral which is enclosed in another is the older of the two. His law has also been modified by stating that the mineral with convex angles at the contact of two individuals is the older. This factor is, however, now shown to depend also on the velocity of growth of the two minerals in different directions, since the slower-growing mineral can be enclosed completely by crystals of the other mineral which started later but grew more rapidly. T. M. L.

689. *Size of the Granules of a Birefracting Solution of Colloidal Iron and the Constant of Avogadro.* **L. Tieri.** (Accad. Lincei, Atti, 32. ii. pp. 155–158, Sept., 1923.)—The study of van t'Hoff upon solutions put in evidence the complete analogy between dissolved substances and gases. The laws of Raoult deduced from that of van t'Hoff are applicable to all dilute solutions, whatever may be the magnitude of the molecules of the dissolved body. Perrin extended the laws of dilute solutions to emulsions supposing that a granule agitated by Brownian motion behaves like a molecule of a body in solution. Such hypotheses, supported by numerous experiments, led Perrin to the determination of the constant of Avogadro. He counted the number of granules contained in equal volumes above four sections at different heights in a column of emulsion in statical equilibrium, and arrived at the result that the law of Laplace on the vertical distribution of molecules of a gas is true also for the granules of a colloidal solution. The law of Laplace extended to an emulsion, whose granules left undisturbed take a distribution in equilibrium on account of Brownian motion and the force of gravity, leads to the equation

$$\mathrm{RT}\log_e(n_0/n) = \mathrm{N}(4/3)\pi a^3(\Delta - \delta)gh$$

in which R is the gas constant, T the absolute temperature n_0 and n the number of grains respectively contained in unit volume of the lower part and of the upper part of a column of height h of the emulsion, N Avogadro's constant, a the radius and Δ the density of the granules, δ the density of the liquid, g the acceleration due to gravity. Taking for the Avogadro constant the value $\mathrm{N} = 60 \times 10^{22}$, $\mathrm{R} = 8 \cdot 3156 \times 10^7$, $\Delta - \delta = 2 \cdot 2$, $\mathrm{T} = 300$, $h = 1$ and $n_{0/n} = 2$ the radius of the granules in a colloidal solution of iron is found to be $1 \cdot 2 \times 10^{-6}$ cm. A. E. G.

690. *Action of Light on Metal Electrodes Giving Small Contact Potentials.* **R. Audubert.** (Comptes Rendus, 177. pp. 818–821, Oct. 29, 1923.)—Two plates of the same metal are placed in an electrolyte and one is illuminated. In many cases this is found to lead to a resultant e.m.f. in the circuit. The effect was observed for the metals platinum, gold, silver, copper, and mercury. About twenty common inorganic salts were used as electrolytes and it was found that the nature of the electrolyte is not of much importance. Platinum, copper, and mercury usually have the illuminated plate for anode, whereas for gold and silver it functions as kathode. Blue light is more active than red. In fact, for each metal there appears to be a treshold value of wave-length to excite the effect. The more electro-positive the metal, the shorter the treshold wave-length. A. A. D.

691. *Free Energy and Heat of Formation of Lead Monoxide.* **D. F. Smith** and **H. K. Woods.** (Am. Chem. Soc., J. 45. pp. 2632–2637, Nov., 1923.)—A magnetically actuated apparatus is described for the circulation of the electrolyte in a cell in order to increase the rapidity of attaining equilibrium between a solid salt and its solution. The e.m.f. of the cell $H_2(g)/Ba(OH)_2/PbO(s) + Pb(s)$ gives the free energy change inthe reaction $H_2(g) + PbO(s) = H_2O(1) + Pb(s)$. This gives $-45,050$ cals. as the free energy of $PbO(s)$ at 25°C., assuming the free energy of liquid water to be $-56,560$ cals. From the temperature coefficient of the e.m.f. and the heat of formation of liquid water, the heat of formation of $PbO(s)$ at 25° C. is found to be $-52,360$ cals. Expressions are derived for the variation of heat-content and free energy with the temperature between 0° C. and 327° C. By the use of low-temperature specific heat data and the "constant entropy" principle, the free energy of PbO(s) at 25° C., calculated from the heat of formation, is −45,460 cals., which is of the usual order of accuracy for calculations based on this method. B. W. C.

692. *A Water-Jacketed Hydrogen Electrode.* **H. S. Simms.** (Am. Chem. Soc., J. 45. pp. 2503–2507, Nov., 1923.)—The cell, which is of the bubbling type, is kept at constant temperature by water from a thermostatic bath, circulated by an air-lift device. This ensures accurate temperature control without interference with the manipulation of the cell. The salt bridge, which is not open to the atmosphere, is formed by potassium chloride solution supplied from a constant level reservoir. The cell is fitted with a special 3-bore, 4-way stopcock, which allows the following operations to be performed: (1) Bubbling of hydrogen through the solution; (2) drainage of a few drops of solution to remove bubbles; (3) drainage of KCl from salt bridge; (4) formation of liquid junction in order to take a reading. Even with solutions of low conductivity accurate readings may be obtained, and a few c.c. will suffice for several consecutive readings. Three minutes' bubbling of hydrogen is sufficient to give results reproducible to 0·01 P_H. B. W. C.

693. *Carbon Cells and the Electro-Chemical Reduction of Metals at High Temperatures.* **L. v. Rhorer.** (Zeits. Elektrochem. 29. pp. 478–488, Oct., 1923.)—The properties of a cell are described in which the anode consists of iron or copper surrounded by its oxide, the kathode of carbon; in the form of coke or retort carbon, and the electrolyte consists mainly of a fused mixture of potassium carbonate and sodium carbonate melting between 690° and 880° C. In order to prevent a reaction which may be violent between the carbon and the carbon dioxide resulting from the dissociation of this electrolyte, it is found necessary to add other compounds, such as barium carbonate or a mixture of lime and magnesia, to the electrolyte. The increased viscosity of the bath produced by this addition is also found to be advantageous. The iron or copper electrode remains in contact with air in its upper part, while the lower part is immersed in the electrolyte. The anode is oxidised by the air and reduced by the current, while the carbon is oxidised by the metallic oxides to carbon monoxide and carbon dioxide. The different disturbing factors are discussed. It is found necessary to protect the oxide from a direct reducing action of the carbon electrode and the reduced metal from re-oxidation by air. Measurements are made with different metallic oxides and at different temperatures of the e.m.f., and the actual electrode potentials of the cell at different intervals on withdrawing a current. A constant potential, which in some cases amounts to 1·45 volts, is obtained for several days on withdrawing a current amounting to 0·1 amp. A calculation of the number of watts produced for unit consumption of carbon show an energy efficiency of from 13 to 18 per cent. allowing for the heat of formation of carbon monoxide from carbon. Small differences of potential are noted with different forms of carbon. By means of the Nernst theorem, a calculation is made from the heats of formation of carbon monoxide and carbon dioxide respectively, from their elements, of the total free energy or maximum work available. At 927° C. the measured potential of 1·25 volt agrees approximately with the value of

1·19 volt, calculated from the heat of formation of carbon monoxide, while the temperature coefficient also shows a good agreement. The thermal data for carbon dioxide agree far less satisfactorily with the potentials observed, and this reaction is therefore considered to be excluded.
J. N. P.

694. *A Study of Polarisation Capacity and Resistance of Electrolytic Cells at Radio Frequencies.* **C. B. Jolliffe.** (Phys. Rev. 22. pp. 293–302, Sept., 1923.)—The investigation refers to Au and Pt electrodes in H_2SO_4 solution for frequencies of 11×10^4 to 2×10^6 cycles per second. The cell was placed in a tuned circuit coupled to a generating circuit, and the polarisation capacity C was computed from the change of capacity required to restore resonance, as indicated by means of a second loosely coupled circuit containing a detector and galvanometer. The polarisation resistance ΔR was obtained by substituting for the cell a variable non-inductive resistance. Both C and ΔR were found to be linear functions of $1/\sqrt{f}$ where f is the frequency. For Au electrodes, the curves all go through the origin, but for Pt the limits for infinite frequency are positive for capacity and negative for resistance, and vary with the concentration. For both Au and Pt the slopes of the capacity curves increase with concentration, while the slopes of the resistance curves decrease. In the case of Au, $2\pi fC\Delta R = \tan \psi =$ const. (nearly), whereas for Pt, $\tan \psi$ varies. These results may be associated with the fact that the residual current is only 1/20 as much for Au as for Pt. The effect of previous polarisation with H_2 is a temporary increase of capacity, while O_2 gives a permanent increase which cannot be removed by polarisation with H_2. The roughness of the surface as well as the previous history affect the values of C and R obtained. Qualitatively the results for C and ψ are in agreement with the theory of Warburg, provided some assumptions are made, but not the results for ΔR. Possible reasons for the discrepancies are suggested.
AUTHOR.

695. *Experiments on the Sign of the Electric Charge Assumed by a Metal Immersed in a Liquid.* **R. D. Kleeman** and **W. Fredrickson.** (Phys. Rev. 22. pp. 134–136, Aug., 1923.)—The nature of the electric charge assumed by a metal plate immersed in a liquid is of importance in connection with the theory of the e.m.f. of a voltaic cell. The charges assumed by various metals and carbon immersed in distilled water was determined by noting the direction of motion of clean wires suspended by a long silk thread when an electric current was passed through the water in which they were immersed. It was found that Ag, Al, Au, C, Cu, Mg, Mo, Ni, Pt, Sn, W, and Zn acquired a negative charge, while Bi, Cd, Fe, and Pb become positive. The electric charge assumed by colloidal particles of Ag, Au, Bi, Fe, Pb, and Pt determined by their motion in an electric field by other observers was found to agree with the results obtained with suspended wires. According to the "Transition-layer Theory" of voltaic e.m.f. previously proposed, this charge is due to the segregation of + H and − OH ions in the layer next the plate as a result of the different rates of diffusion of the two ions.
W. V. M.

696. *The Electromotive Behaviour of Magnesium.* **A. Smits.** (K. Akad. Amsterdam, Proc. 26. 5–6. pp. 395–407, 1923.)—In analogy with the behaviour found with aluminium [see Abstract 186 (1921)], the false or non-equilibrium potentials given by magnesium in salt solutions are attributed to retarding influences on the establishment of internal equilibrium in the ionisation of the metal which occurs in the body of the metal. It was previously found that oxygen, nitric acid, and nitrates have a particularly retarding action. Further evidence is adduced to support the non-validity of the oxide film theory. It is found that a magnesium electrode becomes more negative with increasing concentration of magnesium sulphate or of H ions in an electrolyte, and shows a maximum negative potential for any given concentration of magnesium sulphate at a definite H-ion concentration. The maximum negative potentials thus obtained are, however, not equilibrium potentials, as the metal can be activated by amalgamating to give somewhat higher values which are still below the equilibrium potentials. It is considered that oxides and hydroxides exert a retarding influence on the establishment of internal equilibrium similarly to oxygen and nitric acid, as previously observed. In a solution of magnesium sulphate to which no acid is added, some magnesium hydroxide is in solution and will dissolve in the metal-bounding layer of a magnesium electrode which is immersed in the solution. A magnesium electrode under these conditions dissolves slowly, evolving hydrogen, and shows too low a potential owing to the disturbance of the inner equilibrium. The addition of acid, however, decreases hydrolysis, and with this the magnesium hydroxide content, in the metallic surface, and induces a change in the direction of the inner equilibrium of the metal, so that the potential becomes more strongly negative. Magnesium which has been activated by mercury shows a potential of − 1·856 volt when placed in a solution containing 1 grm. mol. of magnesium sulphate per litre. This value is probably close to the true equilibrium value, but somewhat low owing to the disturbing effect due to corrosion. J. N. P.

697. *Polarisation Capacities with Alternating Current.* **V. Sorrel.** (Comptes Rendus, 177. pp. 639–642, Oct. 8, 1923.)—The author has investigated further the polarisation of small Pt electrodes in dilute sulphuric acid described by P. Vaillant [see Abstract 820 (1919)]. Equilibrium is attained for each value of the current-density before taking observations. Below 5 milliamperes per sq. mm. the capacity increases with progressive increase of the current-density, and the virtual e.m.f. e at the small electrode increases fairly rapidly. When the potential difference applied to the voltameter reaches a certain value the capacity becomes proportional to the current-density, while e remains constant until electrolysis begins. When this occurs, the resistance increases and the capacity decreases, while e reaches a higher value, and then remains constant, as the current-density is increased. Electrolysis does not commence until a higher value of the current-density is obtained than that observed by Vaillant if the above procedure is followed. Further, on diminishing the current the electrolysis does not cease until a lower figure is obtained. The value of e therefore depends upon the method of attaining equilibrium. Temperature has no effect upon the capacity of the electrode. The capacity increases slightly as the concentration of the sulphuric acid is diminished. B. W. C.

698. *Moving Boundary Method for Determining Transference Numbers.* **D. A. MacInnes** and **E. R. Smith.** (Am. Chem. Soc., J. 45. pp. 2246–

2255, Oct., 1923.)—Denison and Steel's method for determining transference numbers [Abstract 802 (1906)] is modified so that only a single moving boundary is required. It is found that the boundaries move with the theoretical velocities only when the two solutions in contact at a boundary are adjusted to within about 5 per cent., to the relation $C/T = C'/T'$, in which C and C′ are the concentrations and T and T′ the transport numbers. The correct value for T can therefore be obtained by a series of experiments in which this condition is continually approached more and more closely. Unless this adjustment is obtained, the results are independent neither of the composition of the indicator solution nor of the current passing through the apparatus and may vary widely and erratically from the true values. The values obtained for the transference numbers at 25° for potassium chloride and bromide in 0·1 N solutions show that the conductivity of the potassium ion is the same in the two solutions provided that a correction for the viscosity is applied. T. H. P.

699. *Periodic Phenomena on the Electrolysis of Chromic Acid.* **A. Kleffner.** (Zeits. Electrochem. 29. pp. 488–491, Oct., 1923.)—Electrolysing chromic acid with electrodes of iron, chronium or platinum Liebreich [Abstracts 682 and 1821 (1922)] observed periodic fluctuations in current and potential which he ascribed to special reactions and not to passivity. Callenberg (unpublished dissertation) having found that the periodicity only took place when the chromic acid contained some sulphuric acid, from which it is difficult to free it, the author experimented with pure chromic acid, free or not free of sulphuric acid. He confirms Callenberg, thus questioning Liebreich's reactions which did not allow for the participation of sulphuric acid. The more concentrated the chromic acid, the more sulphuric acid is required to make the phenomena unsteady. Any unsteadiness observed is due to the condition of the kathode. H. B.

700. *Anomalous Properties of Chromium and its Behaviour during Electrolysis.* **N. Isgarischew** and **A. Obrutschewa.** (Zeits. Elektrochem. 29. pp. 428–434, Sept., 1923.)—Previous work on the passive state and variable valency of chromium is reviewed. Experiments are described which support the view of the authors that the passivity is due to the existence of a colloidal film of oxide on the surface of the metal. This explains the effect of chlorine ions and various anions and kations on the passivity, which could not be accounted for by previous theories. The solubility of chromium during electrolysis in direct current, alternating current, or a combination of the two, is observed in acid, neutral, and alkaline solutions. The proportions of bivalent, trivalent, and hexavalent chromium are determined in each case, and their relative amounts explained satisfactorily on the assumption that a colloidal film of oxide exists on the metal surface. B. W. C.

701. *Effect of Short-Circuits on the Passivity of Iron Electrodes.* **C. F. Holmboe.** (Zeits. Elektrochem. 29. pp. 530–534, Nov., 1923.)—It is observed that the current taken by a battery of electrolytic cells consisting of iron electrodes in caustic soda solution is considerably greater after the battery has been short-circuited than after it has been completely shut off. As no appreciable rise in pressure occurs in the gas receivers during the short-circuit, normal electrolysis cannot be taking place. The influence of electrolysis on the passivity of the electrodes provides a satisfactory explanation. A hydrogenated complex forms at the kathode and the anode becomes oxygenated; on connecting the electrodes after electrolysis these effects will be reversed, the kathode becoming oxygenated and the anode hydrogenated. When the current is switched on again an increased strength will be required, as is observed in the author's experiments. B. W. C.

702. *Absorption of Carbon Dioxide by Caustic Soda during Electrolysis.* **C. F. Holmboe.** (Zeits. Elektrochem. 29. pp. 535–537, Nov., 1923.)—Experiments made in the laboratory and in factories on the absorption of CO_2 from the air during the electrolysis of caustic soda solution in open cells for the production of hydrogen and oxygen and the diminution of electrolytic conductivity due to this absorption. The conductivity of Na_2CO_3 is about one-fourth that of NaOH. In works the number of grammes of Na_2CO_3 per cm.^{3} of NaOH solution may rise to 12·5 in the course of two years; starting with 1 gr. per cm.^{3} the dilution will contain about 7·5 gr. Na_2CO_3 after 1½ years; the quantity increases with intermittent working. Technically the lye should be renewed after this time. H. B.

703. *Hydrogen Overvoltage and Current-Density in the Electro-Deposition of Zinc.* **U. C. Tainton.** (Am. Electrochem. Soc., Trans. 41, pp. 389–410, 1922.)—The author reaches the conclusion that the continued deposition of metallic zinc from solutions depends on the maintenance of a high hydrogen overvoltage at all points of the kathode surface. This is attained by the maintenance at all points of a substantial current-density. By sufficiently increasing the current-density the overvoltage of all metals examined may be made to exceed the potential of zinc on the hydrogen scale. In the case of zinc deposits containing impurities the overvoltage is very high as long as the zinc surface is clean and growing. On the other hand, the voltage of an impure, corroded zinc surface is very low, and therefore once corrosion begins it tends continually to spread. Colloidal matter, such as gelatin, in the electrolyte raises the overvoltage of hydrogen. W. R. C.

704. *Alternating Current in Direct-Current Electrolysis.* **W. B. Jones.** (Am. Electrochem. Soc., Trans. 41. pp. 151–180, 1922.)—In this investigation a rotating contact was used so that measurements could be made at any point of the cycle (0·04 sec.). Lead electrodes were used in sulphuric acid. The relation of alternating current to direct-current varied in the investigation so that in some cases no reverse currents were obtained, but in others there was a reversal of current. When the potential is plotted against the current flowing and a correction is made for the drop through resistance, the curves indicate the formation of stable and unstable hydrides and oxides as films on the kathode and anode respectively. The author considers that these are the cause of overvoltage. Measurements with intermittent direct-current give the approximate stability of the lead hydride so formed. The maximum overvoltage attained during kathodic action is only slightly lowered by superimposing increasing amounts of alternating current. W. R. C.

705. *Intermittent Current Electrolysis. Part II. Overvoltage Study of the Lead Electrode.* **S. Glasstone.** (Chem. Soc., J. 123. pp. 2926–2934, Nov., 1923.)—This is a continuation of the investigations to which reference was made in Abstract 176 (1924). It refers particularly to the lead electrode. A special commutator was used so that the polarised electrode could be connected with the potentiometer at any portion of a complete cycle in the intermittent method. By varying the speed of the commutator an estimate could be made of the rate of fall of potential after switching off the polarising current. By altering the resistance, inductance and capacity the effect of induced currents could be examined. Results are given for three values of inductance. It is pointed out that error in the direct-current measurement may amount to 0·12–0·18 volt at a current-density of 0·025 ampere per sq. cm. Thus potentials measured by the direct method are too high. Similarly potentials measured by the commutator method may be too low. W. R. C.

706. *Overvoltage Measurements.* **H. J. S. Sand** and **E. J. Weeks.** (Chem. Soc., J. 123. pp. 2896–2901, Nov., 1923.)—A criticism of Glasstone's work on this subject [Abstract 176 (1924) and preceding abstract]. The authors contend that there are several errors in Glasstone's arrangement, and that all his conclusions are consequently invalid. Intermittent current overvoltages are found to be independent of self-inductance of the circuit over a much wider range than is likely to occur in experimental investigations. W. R. C.

707. *Corrosion of Electrolytic Iron.* **W. E. Hughes.** (Chem. and Met. Eng. 29. pp. 536–537, Sept. 17, 1923.)—Attention is drawn to the necessity of employing pure iron in research. Electrolytic iron is not necessarily pure, and it may vary considerably in the extent of its impurities. Photographs of specimens of electrolytic iron are reproduced showing that iron deposited from a chloride bath is much more liable to rust than iron deposited from a sulphate bath. W. R. C.

708. *Electrolysis with an Aluminium Anode, the Anolyte being:* (1) *Sodium Nitrite Solutions,* (2) *Potassium Oxalate Solutions.* **F. H. Jeffery.** (Faraday Soc., Trans. 19. pp. 52–55, July, 1923).—(1) In this case the primary product of the reaction at the anode is probably aluminium nitrite, which is hydrolysed rapidly to hydrated aluminium oxide and nitrous acid, the latter then giving rise to nitric oxide and nitric acid. No evidence is obtained of the formation of a complex anion of aluminium. (2) With potassium oxalate solutions the product of reaction at the anode is a complex anion derived from aluminium, the salt $K_3[Al(C_2O_4)_3].3H_2O$ being obtainable from the anolytes after electrolysis; this method of formation would indicate the salt to be a true complex salt comparable with potassium chromioxalate, in which case it may be represented in three dimensions. The isolation of a complex salt from an anolyte does not imply necessarily that the constitution of the anionic part of this salt is identical with that of the complex anion present in the anolyte after electrolysis. An attempt has been made to examine the complex anion in solution by the electrometric method developed for the investigation of the plumbo-nitrite complex $[Pb(NO_2)_4]$ [see Abstract 115 (1923)]. It is, however, found that an aluminium electrode immersed in a solution of potassium oxalate containing a known concentration of the potassium alumini-oxalate exhibits a potential which is so variable as to be useless for trustworthy determinations. T. H. P.

709. *Electrolytic Preparation of Para-Aminophenol.* **J. C. Warner** and **O. W. Brown.** (J. Phys. Chem. 27. pp. 652–673, Oct., 1923.)—In the electrolytic reduction of para-nitrophenol to para-aminophenol [see Abstract 1703 (1923)], lead gives better results than copper as the kathode metal and also permits of the use of higher current-densities. The conditions for obtaining the highest yields of the amino-compound have been investigated and the results are given in detail. [See also Abstract 364 (1924)]. T. H. P.

710. *The Kathodic Reduction of Ketones (Menthone).* **C. Schall** and **W. Kirst.** (Zeits. Elektrochem. 29. pp. 537–546, Nov., 1923.)—The reduction of menthone by means of metallic sodium in alcohol or ether being dangerous, Law [Abstract 1788 (1912)] applied reduction by means of electrolytic hydrogen from lead kathodes in sulphuric acid ; he obtained menthol and pinacones. The authors resume this research. The anode compartment of their closed cell contains a perforated lead cylinder and sulphuric acid in a porous pot ; outside is a cooling coil and the kathode of pure lead, mercury, or cadmium (also copper, platinum, or palladium) ; the *l*-menthone is dissolved in 99 per cent. alcohol. Alkaline solutions gave poor yields. The reduction yielded *l*-menthol and other products, and there was no appearance of depolarisation (except faintly with copper) ; this is contrary to Tafel's experience with caffeine and succinimide. The kathode potential rose to a maximum (this rise being slow with cadmium) and then diminished again. Lead kathodes prepared after Tafel gave essentially *l*-menthol ; roughened, but bright, lead gave menthone ; pinacone was found when the diaphragm was not used ; whether or not Law had a diaphragm is not certain ; cadmium kathodes gave almost exclusively hexahydrocymene, especially in strongly acid solution. With mercury kathodes unstable compounds of mercury with menthyl were obtained ; being viscous and hardly soluble in alcohol, these compounds cover the mercury with a non-conducting film which is broken up by hydrogen bubbles. The authors consider that the hydrogen enters the carbonyl CO-group in contact with the kathode in forming these organo-metallic compounds ; those with lead and cadmium were still more unstable than the mercury menthyl. H. B.

711. *Electrolytic Deposition of Chromium.* **K. Oyabu.** (Zeits. Elektrochem. 29. pp. 491–493, Oct., 1923.)—F. Sulzer (D.R.P. 221472 of 1907) observed that chromium was better deposited from chromic acid than from salts of lower valency. The author discusses this and expecially the experiments of Sargent [Abstract 1640 (1921)], of Liebreich [Abstract 2342 (1923)] and of his own without arriving at any final view as to the actual mode of deposition of metallic chromium. H. B.

712. *The Nature of the Oxide Formed at the Anode during the Electrolysis of Solutions of Thallium Sulphate.* **A. Gutbier** and **W. Dieterle.** (Zeits. Elektrochem. 29. pp. 457–467, Sept., 1923.)—An examination is made of two methods which have formerly been described for the quantitative estimation of thallium by anodic separation of the oxide from a thallium sulphate solution. It is shown that the oxide formed in this way contains, in all cases, sulphuric acid, and the methods are therefore not applicable to the exact estimation of thallium. A method is described whereby the oxide can be produced anodically in a form suitable for analysis and possessing a high resistance against chemical influences. The anodically separated oxide is shown to be of the composition Tl_2O_3 by means of the three following procedures: (*a*) Reduction of the oxide in hydrogen and weighing the water formed. (*b*) Reduction of the oxide by sulphurous acid and estimation of the sulphuric acid formed. (*c*) Measurement of the current produced by the electro-chemical reduction of the oxide deposited on the interior of a platinum basin which contains an electrolyte and a zinc pole as kathode. J. N. P.

713. *Electrostatic Phenomena during the Electrolytic Production of Gas Bubbles. Parts I and II.* **A. Coehn** and **H. Neumann.** (Zeits, f. Physik, 20. 1. pp. 54–67, and 68–81, 1923.)—*Part I Deals with Electrostatic Attraction and Bubble Dimensions.*—In a previous paper Coehn and Mozer [see Abstract 1322 (1914)] found that the gas bubbles evolved during electrolysis differed greatly according as the electrolyte was acidic or alkaline, the difference being especially pronounced at kathodic hydrogen development; where from alkali the hydrogen rises in fine drops, whereas from acid it adheres to the electrode and only rises when large bubbles are formed. The cause is ascribed to electrostatic effects. It has now been established experimentally that the attraction of gas bubbles at the solid electrode, which is always to hand from capillarity forces, may, for electrolytically produced gases, (*a*) be increased if the gas bubble and electrode possess opposite signs, (*b*) be diminished if they have like signs and the potential of the electrode suffices for overcoming the capillary attraction. Bubbles which adhere only by capillary attraction have the same dimensions in all dilute solutions under the same experimental conditions. Those held by electrostatic forces grow with the strength of the electrolyte which has the opposite charge to the electrode. Sense and magnitude of the electrostatic force are derived from another type of phenomena to the bubble effect. The curves giving the connection between the concentration of a solution and the charge on the bubbles travelling through it, give also information on the adherence and magnitude of the electrolytically developed gas bubbles.

Part II Considers Electrostatic Repulsion and the Gas-Emitting Electrode.—When the electrolytically developed gas bubbles and the electrodes have like charges, then at a sufficiently high electrode potential the bubbles are repelled and there arises the gas-emitting electrode. The potential required is lower as the bubble charge is greater, and can be determined like the effect of electrostatic attraction from the curves for the bubble effect showing the dependence of gas charge on concentration. From the emission potential concentration curves the duration of the effect can be obtained. After cessation of the first emission, with very fine bubbles, a second emission with large bubbles appears by increase of potential at both electrodes and for all concentrations. In contrast to the first emission this is traced to the influence of the strong electric field at the electrode on the distribution of the ions in the liquid layer containing the gas bubbles. H. H. Ho.